IMPROVING FIRE APPARATUS LIFE SPAN PROJECTIONS IN THE NORFOLK DEPARTMENT OF FIRE AND PARAMEDICAL SERVICES

FIRE SERVICE FINANCIAL MANAGEMENT

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ABSTRACT

Fire apparatus replacement intervals should be based on the estimated effects of variables such as age, use, and maintenance costs on useful life span. The problem was the replacement intervals of the Norfolk Department of Fire and Paramedical Services were based exclusively on age.

The purpose of this research project was to examine variables that may affect useful life span, compare planned replacement intervals with projected life spans, examine the replacement practices of other fire departments, and identify steps to improve fire apparatus life span projections. Descriptive research was used to answer the following questions:

1. What are the ages, mileage totals, unit activity levels, maintenance costs, and performance test results of NFPS fire apparatus?

2. What is the operating condition and performance level of each fire apparatus in the NFPS fleet, as judged by fire apparatus operators?

3. How do the planned replacement intervals of the NFPS compare to the remaining useful life spans of fire apparatus, as projected by fire apparatus operators?

4. What variables do other local fire departments examine when assessing fire apparatus for replacement?

The procedures used to complete this research consisted of a literature review, a records review, an apparatus survey, and a fire department survey.

The results of this research included the substantiation of the research of others, the discovery of practices that were incongruent with the recommendations of others, the identification of varied apparatus operating conditions and performance levels, the detection of

shortcomings in planned replacement intervals, and the discovery of an objective apparatus assessment process.

The recommendations of this research project included the development of apparatus programs to manage and analyze data, assess operating condition, and test performance. Also included were recommendations to search for alternatives for extending life spans, and to educate others about fire apparatus needs.

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INTRODUCTION

One of the most important capital assets of a municipal fire department is a fleet of reliable automotive fire apparatus. Firefighters depend heavily on the performance capabilities of these vehicles when delivering emergency services to protect life, property, and the environment (Peterson, 1994). If these services are to be provided without interruption, fire apparatus must be maintained in superior operating condition and should be promptly replaced when adequate performance levels can no longer be assured (Peters, 1994).

Replacing fire apparatus is a necessary yet costly expenditure of public funds. The purchase price of modern fire apparatus can range from $100,000.00 to beyond $500,000.00, and depends largely on the type of apparatus and the systems and ancillary equipment specified (Peters, 1996). Although the cost involved with the purchase of a single fire apparatus may appear small when compared to the fund balance of the average local government, the need to purchase multiple units during a single fiscal year can place a severe financial burden on any municipality. Accordingly, fire apparatus replacement should be a carefully planned process that is conducted at regular intervals (Peters, 1994; Peterson, 1994).

Replacement intervals should be based on the estimated effects of variables such as age, use, and maintenance costs on the useful life span of fire apparatus (Commission on Fire Accreditation International, 1997; Cottet, 1992). Replacement intervals should also account for the time required to prepare bid specifications, conduct bid processes, and construct and deliver apparatus (Peterson, 1994). The problem that prompted this research was the fire apparatus replacement intervals of the Norfolk Department of Fire and Paramedical Services (NFPS) were based exclusively on the estimated effects of age on the useful life span of fire apparatus. This practice failed to take into account other variables that affect the useful life span of fire apparatus. The purpose of this research project was to examine variables that may affect the useful life span of NFPS fire apparatus, compare the planned replacement intervals with the projected remaining life span of NFPS fire apparatus, examine the fire apparatus replacement practices of other local fire departments, and identify the steps that should be taken by the NFPS to improve fire apparatus life span projections. This research project employed a descriptive research methodology to answer the following questions:

1. What are the ages, mileage totals, unit activity levels, maintenance costs, and performance test results of NFPS fire apparatus?

2. What is the operating condition and performance level of each fire apparatus in the NFPS fleet, as judged by fire apparatus operators?

3. How do the planned replacement intervals of the NFPS compare to the remaining useful life spans of fire apparatus, as projected by fire apparatus operators?

4. What variables do other local fire departments examine when assessing fire apparatus for replacement?

The procedures used to complete this research project included a literature review, a review of Norfolk City records, a survey of NFPS fire apparatus, and a survey of the fire apparatus replacement practices of other fire departments in the Tidewater Metropolitan Area.

BACKGROUND AND SIGNIFICANCE

The NFPS was formed in April 1991, by the merger of the Norfolk Fire Department (NFD) with the Bureau of Paramedical Rescue Services (BPRS). The department employs 490 personnel and protects a 66 square mile urban city with an estimated population of 229,400. Services provided by the department include fire protection, emergency medical, technical rescue, hazardous materials, fire code enforcement, fire investigation, and public education. The department is divided into four divisions: operations, fire prevention, training, and administration. Emergency services are provided by the operations division, which is comprised of 3 battalions, 15 fire stations, 14 engine companies, 7 ladder companies, 2 squad companies, and 10 rescue units. The annual operating budget for the department is $23.9 million (City of Norfolk, 1998).

Prior to the merger of the NFD with the BPRS, funding for fire apparatus replacement was included each year in the NFD's operating budget. This funding allowed the purchase of a new fire pumper every one to two years and an aerial ladder every four to six years, which ensured an efficient, reliable, and serviceable fleet of first-line fire apparatus. In addition to purchasing new apparatus, NFD mechanics rehabilitated several older units during the early and middle 1980s. Beginning in Fiscal Year 1988, NFD administrators were forced to cut fire apparatus replacement funding in order to meet citywide budget reduction mandates. In the absence of a regular replacement process, it became necessary to keep fire apparatus in service for longer periods of time. As a result, the average age of the fire apparatus in the NFD fleet began to increase, and the operating condition and performance levels of many older units steadily declined. This situation was compounded by the loss of one first-line fire pumper in 1989 due to a serious traffic accident.

Following the merger of the NFD and the BPRS, the role of Norfolk's fire apparatus in the delivery of emergency services was significantly expanded. In addition to fire protection equipment, fire apparatus were stocked with basic and advanced life support equipment, technical rescue equipment, and hazardous materials response equipment. Unfortunately, many of the department's apparatus had been purchased during the 1960s and 1970s and were not designed to accommodate these additional equipment loads. Some units lacked adequate storage compartments for sensitive equipment such as drug boxes and electronic monitors, whereas the combined weight of added equipment exceeded the gross vehicle weight ratings of other units. In response to these problems, city management approved the use of contingency and special revenue funds to purchase four new fire pumpers and one heavy rescue vehicle during Fiscal Year 1991 (Senter, 1998).

During subsequent years, NFPS administrators lobbied unsuccessfully to have funding restored for regular fire apparatus replacement. Although city management had been willing to support the purchase of multiple fire apparatus to meet immediate service delivery needs, there was no appreciable support for a multi-year replacement plan that would ensure continued operational performance of the NFPS fleet without imposing a financial burden on the city during any single fiscal year.

In early 1993, serious concerns about the reliability and serviceability of both first-line and reserve fire apparatus began to surface. During that year, NFPS administrators received numerous complaints from firefighters about equipment failures at emergency scenes. In addition, the city's fleet manager reported an increase in maintenance costs and a shortage of replacement parts for vehicles that were beyond 20 years of age. Frustrated by the deteriorating condition of the fire apparatus fleet and the lack of political support for regular replacement, members of the Norfolk Professional Firefighters Association (NPFF), Local 68 of the International Association of Firefighters (IAFF), initiated a campaign to increase public awareness and build political support for the purchase of new fire apparatus. The condition of the NFPS fleet was also highlighted by a series of investigative reports that was aired by the local ABC News affiliate (Senter, 1997).

In response to the NPFF's public awareness campaign and the news reports on the state of the NFPS fire apparatus fleet, the Norfolk City Council directed the city manager to investigate the problem and take corrective action. In July 1993, a task force was established to assess the condition of the existing fleet, identify the necessary apparatus requirements to meet the mission of the department, and recommend a manageable replacement schedule for older units. The efforts of the task force members culminated in a comprehensive vehicle study that included a survey of all first-line and reserve fire apparatus, an overview of the organizational goals and service demands of the NFPS, a comparative analysis of the fire apparatus replacement programs in other jurisdictions, and a proposed apparatus replacement schedule (Senter, 1998).

The survey of the existing fire apparatus showed that the average ages of first-line apparatus had reached 11.1 years for engine companies, 18.1 years for ladder companies, and 6.5 years for squad companies. A significant number of first-line and reserve engines and ladders were beyond 20 years of age, some of which exceeded the National Fire Protection Association's (NFPA) maximum recommended life span by 5 to 10 years.

The review of NFPS organizational goals and service demands reflected a change from previous years in the types of services the department was providing. This trend was confirmed by an analysis of Virginia Fire Incident Reporting System (VFIRS) data, which showed that while total call volume remained high, actual fires accounted for only 12.2% of all emergency responses by fire apparatus. The remaining responses consisted of emergency medical calls (56.3%), false/unintentional/system malfunctions (16.1%), hazardous conditions (6.4%), other calls (4.7%), and general service calls (4.2%). Despite a low occurrence rate of fires, several major fires that occurred during 1993 in multi-family occupancies constructed of lightweight wood construction underscored the need for increased fire-flow capabilities. Based on the organizational goals of the new department and the changes in service demands, the task force recommended various performance enhancements for future fire apparatus in an effort to improve personnel safety, ensure reliability, and increase operational efficiency.

The comparative study of the fire apparatus replacement practices of other jurisdictions included a survey of the Cities of Newport News, Portsmouth, Richmond, and Virginia Beach, and the County of Fairfax, Virginia. This study revealed that four out of the five localities surveyed followed specific replacement intervals for fire apparatus based on useful life span projections that ranged between 12 and 18 years of first-line service.

The proposed fire apparatus replacement schedule was structured to promptly improve the condition of the NFPS fleet during the first five years, and ensure long-term reliability and serviceability of the fleet through regular apparatus replacement during later years with the ultimate goals of (a) replacing fire pumpers and aerial ladders every 20 years including 15 years of first-line service and 5 years of reserve service, and (b) replacing heavy rescue vehicles every 15 years including 10 years of first-line service and 5 years of reserve service (NFPS, 1993). After reviewing the proposed replacement schedule and ordering several revisions, the city manager approved the use of master-lease financing to fund a multi-year fire apparatus replacement program (D. L. Burcham, personal communication, December 29, 1993).

The initial phases of the program were implemented during Fiscal Years 1995 through 1998, and involved the accelerated purchase of three to five apparatus each year to replace those units that had become unreliable, unserviceable, or obsolete. During this time 12 units were replaced, which accounted for nearly half of the NFPS first-line fire apparatus fleet and a total capital outlay of approximately $4.9 million. It was projected that subsequent years would involve the purchase of fewer units each year until the planned replacement intervals for each type of apparatus were met (E. L. Senter, personal communication, January 10, 1999).

Norfolk has long been considered the most fiscally stressed city in the Commonwealth of Virginia. Due to an out-of-balance housing market, the development of 92% of all available land, and an assessed real estate value of which 48% is tax-exempt, the city's ability to raise additional revenue is severely limited. As a result, the city is often forced to assume debt to finance improvements in infrastructure and replacement of capital assets (City of Norfolk, 1998). The procurement of multiple capital assets during a single budget cycle increases debt ratios and threatens the city's bond rating for future loans and investments.

If city management is to be successful in improving the financial position of the city, the practice of replacing multiple capital assets during a single fiscal year must be avoided in the future. Proper planning based on objective projections of useful life span will ensure that capital assets such as fire apparatus are replaced at reasonable intervals, without straining the fiscal resources of the city during any single budget cycle.

This research project was completed in accordance with the applied research requirements of the National Fire Academy’s Executive Fire Officer Program. The problem addressed by this research project related specifically to Unit VIII of the *Fire Service Financial Management* course, titled *Budget Management*. In this unit of instruction, students were introduced to the importance of projecting the useful life span of assets as part of the purchasing process. It was anticipated that the recommendations resulting from this research would also be helpful to other fire departments seeking ways in which to improve fire apparatus life span projections.

LITERATURE REVIEW

Estimating the Useful Life Span of Fire Apparatus

The writings of various authors (Craven, 1997; Peters, 1994, 1995; Peterson, 1994) suggested that the useful life span of fire apparatus varies among fire departments and is affected largely by apparatus utilization, local environment, local operating conditions, and scope of regular preventive maintenance. The life span of fire pumpers subjected to moderate and heavy use was estimated at 10 to 15 years, while the life span of aerial ladders subjected to light and moderate use was estimated at 15 to 20 years. Conversely, the life span of fire apparatus subjected to very light use was estimated at 20 years, whereas the life span of fire apparatus subjected to extremely heavy use was estimated at less than 10 years.

These authors agreed that a piece of first-line fire apparatus that has reached the end of its useful life span for front-line emergency service may be placed in reserve status for a reasonable time period, provided the vehicle remains in good operating condition and receives regular preventive maintenance. Peters (1994) noted that the NFPA recommends the replacement of any fire apparatus that is beyond 25 years of age. Peters (1995) and Peterson (1994) warned that fire apparatus beyond 25 years of age may not be reliable, and should not be depended upon for front-line emergency service.

Craven (1995) identified three categories of fire apparatus life span: service life, technological life, and economic life. Service life was defined as the length of time that a piece of fire apparatus can be expected to perform in a functional and reliable manner, under the service demands and operating conditions to which it is exposed. Technological life was referred to as the ability of fire apparatus to continue to perform in a functional and reliable manner when changes in service demands, technology, and performance standards occur.

Finally, economic life was described as the length of time that fire apparatus can be operated and maintained in a cost-effective manner.

The Effects of Age on the Useful Life Span of Fire Apparatus

In 1991, Capitol Safety Systems identified age as the variable most often referenced by fire departments when evaluating fire apparatus for replacement. Peters (1994) explained that age is considered an important variable in fire apparatus replacement decisions, because the potential for mechanical failure typically increases with age.

Peters described the demands that are placed on first-line fire apparatus including emergency responses, repeated acceleration and deceleration cycles, frequent defensive driving maneuvers, and high engine speeds prior to sufficient engine warm-up. The environmental conditions under which fire apparatus are operated were noted to be at times less than ideal. It was also noted that fire apparatus are often operated at both high and low intensity levels for extended periods of time. Although the preventive maintenance and care that fire apparatus typically receive was regarded by Capitol Safety Systems (1991) as excellent, Peters (1994) stressed that the long-term cumulative effects of emergency responses and extreme operating conditions result in reduced performance levels and fatigued mechanical components and assemblies.

An age-related problem identified in the fire service literature was the availability of parts for older fire apparatus. It was emphasized that fire departments operating fire apparatus produced by manufacturers who are no longer in business may experience difficulty in obtaining replacement parts for cab and body assemblies and aerial devices. It was noted that in some cases it might be necessary to purchase remanufactured or custom fabricated parts to keep older units in service. In addition, it was noted that equipment distributors who supply component parts such as engines, transmissions, axles, and pumps, may discontinue stocking standard replacement parts within a reasonable time period after older model components are phased out of production (Peters, 1994, 1995).

Various authors (Capitol Safety Systems, 1991; Carter & Rausch, 1989; Peters, 1994) stressed that age should not be the only variable considered in replacement decisions. In addition to age, other variables such as maintenance costs and "downtime" were recommended for consideration.

The Effects of Maintenance Costs on the Useful Life Span of Fire Apparatus

Several authors (Craven, 1995; Peters, 1994) implied that positive relationships often exist between variables such as apparatus age, service demands and patterns of use, and maintenance costs.

Peters (1994) wrote about the effects of age on the maintenance requirements of the mechanical and structural components of fire apparatus. It was suggested that as a piece of fire apparatus ages it requires maintenance and repair on a more frequent basis, which increases maintenance costs. In addition to increased maintenance and repair frequencies, it was noted that the replacement parts for older apparatus might be more costly to obtain.

Craven (1995) addressed the effects of changes in service demands on maintenance costs. It was implied that an increase in call volume might result in a corresponding increase in maintenance requirements. Capitol Safety Systems (1991) raised a similar issue concerning patterns of use. It was suggested that fire apparatus are regularly subjected to the inconsistent driving and operating patterns of personnel who have varied skill and experience levels, which may lead to an increase in the frequency of repairs.

Craven (1995) described the ways in which fire apparatus maintenance costs may be analyzed including total charges for parts and labor, maintenance cost per mile, and downtime. It was noted that when maintenance costs reach a point of diminishing returns, replacement of the apparatus might be the most cost-effective solution.

In addition to examining total maintenance costs and downtime, the CFAI (1997) recommended that replacement decisions include an analysis of maintenance data such as incidents of mechanical failure or number of mechanical defects.

The Effects of Performance Testing on the Useful Life Span of Fire Apparatus

Fire apparatus performance testing was considered by Peters (1994) to be an important step in ensuring acceptable fire apparatus performance levels. The CFAI (1997) recommended that all performance testing be conducted in accordance with nationally recognized standards, such as those developed and published by the NFPA.

A review of NFPA 1911, titled *Standard for Service Tests of Fire Pump Systems on Fire Apparatus* (1997), revealed that all apparatus equipped with fire pumps are required to undergo performance tests annually, or whenever the pump or associated equipment is modified or repaired. These tests include (a) engine speed check, (b) vacuum test, (c) pumping test, (d) pressure control test, (e) gauge and flow meter test, (f) tank-to-pump flow rate, and (g) any other tests mandated by the local fire department.

A review of NFPA 1914, titled *Standard for Testing Fire Department Aerial Devices* (1997), revealed that all apparatus equipped with an aerial device are required to undergo performance tests annually, or whenever the aerial device or associated equipment is modified or repaired. These tests include (a) service record inspection, (b) complete inspection and operational tests of the aerial device and all associated systems and components, (c) chemical analysis of hydraulic fluid, (d) load testing of the aerial device, and (e) flow and pressure tests of aerial device waterways. In addition to these tests, this standard requires the nondestructive testing of aerial devices every five years, or whenever problems are identified or suspected as a result of the inspection or performance testing processes. Non-destructive tests may include (a) ultrasonic pulse-echo straight-beam examination, (b) manual ultrasonic pulse-echo contact test, (c) magnetic particle examination, (d) liquid penetrant examination, (e) radiographic examination of weldments, and (f) metallic hardness tests.

The NFPA recommends that if an apparatus fails any performance test, it should be placed out of service until repairs can be made. Peters (1994) noted that in some cases these repairs may require the investment of considerable funds and it may be more cost-effective to replace the apparatus altogether.

The Effects of Unplanned Replacement on the Useful Life Span of Fire Apparatus

Peters (1994) identified damage from vehicular accidents, exposure to radiant heat, and falling debris from collapsing structures, as common reasons for the unplanned replacement of fire apparatus. The need to replace apparatus due to accidental damage was considered easier to justify to municipal leaders, elected officials, and citizens. However, it was noted that insurance settlements might not cover the full cost of replacement, which may force a municipality to provide the balance of funding, often at the expense of other programs or projects.

The Effects of Obsolescence on the Useful Life Span of Fire Apparatus

Craven (1995) addressed the issue of obsolescence as it relates to fire apparatus performance requirements. A fire apparatus is often considered obsolete when "emergency crews cannot use the vehicle because it is not suitable for use or new technology is available to make the job or task more efficient" (p. 87). It was suggested that in many cases, obsolescence drives apparatus replacement decisions more so than age or maintenance costs.

In 1998, Senter described the challenge of storing an array of modern emergency equipment on older apparatus that were designed solely for fire protection. Peters (1994) suggested that in some instances older apparatus may become obsolete when the additional equipment loads required by modern fire departments exceed the gross vehicle weight ratings, resulting in a reduction in the performance of drive trains and braking systems and an increase in stress on chassis suspension systems and body assemblies.

Peters (1995) addressed the increased reliance on twelve-volt electrical systems during recent years, to supply power to apparatus enhancements such as additional emergency lighting packages and air conditioning systems. It was noted that the alternator and electrical system capacities of older apparatus may be considered obsolete and incapable of meeting these increased power demands.

In an effort to provide cost-effective emergency services, many fire departments have incorporated the concept of operational efficiency into the design of new fire apparatus. Capitol Safety Systems (1991) suggested that recent trends in the fire service have included a shift from basic, single function apparatus to technologically advanced units that are capable of multiple functions. The writings of Peters (1994, 1995) demonstrated the cost-effective service enhancements that are possible with multi-function apparatus such as quints, rescue pumpers, and fire pumpers with patient transport capabilities. In addition, Capitol Safety Systems (1991) suggested that the introduction of new vehicle technology including diesel engines, automatic transmissions, secondary braking devices, improved steering systems, high capacity fire pumps, and the use of aluminum in the construction of cab and body assemblies has resulted in greater fuel economy, and improvements in acceleration, deceleration, maneuverability, emergency operation, and corrosion resistance. It was noted that older apparatus may not be capable of meeting these modern expectations of operational efficiency and may be considered obsolete (Peters, 1994, 1995).

The Effects of Non-Compliance with Safety and Consensus Standards on the Useful Life Span of Fire Apparatus

The literature review revealed three standards that have greatly influenced the design and construction of fire apparatus. These standards included the Federal Motor Vehicle Safety Standards (FMVSS), NFPA 1500, titled *Fire Department Safety and Health Program,* and NFPA 1901, titled *Standard for Automotive Fire Apparatus*.

In accordance with the National Traffic and Motor Vehicle Safety Act of 1966, the National Highway Traffic Safety Administration promulgated the FMVSS to serve as minimum mandatory performance requirements to ensure safe operation and occupant protection for all motor vehicles manufactured in the United States including fire apparatus. These standards address a number of safety issues related to occupant protection and the function of vehicle systems and mechanical components (National Institute of Emergency Vehicle Safety, Emergency Vehicle Safety Symposium, June 14-15, 1994).

National Fire Protection Association 1500 (1992) and NFPA 1901 (1996) address safety issues in the design of fire apparatus including fully enclosed cabs, seat belts for all riding positions, and maximum permissible sound levels within cab and crew cab areas. National Fire Protection Association 1901 (1996) also establishes minimum tip-load ratings for aerial devices, minimum fire pump and booster tank capacities, and minimum storage capacities for equipment compartments and hose storage areas.

Because older apparatus are not required to comply with modern safety and consensus standards, Peters (1994, 1995) noted that it might be difficult to justify replacing existing apparatus solely on the basis of non-compliance. However, Peterson (1994) stressed that the existence of a serious safety issue may warrant replacement and should not be overlooked.

Collection of Data to Support Fire Apparatus Replacement Recommendations

Various authors (Brown, 1992; Cottet, 1992; CFAI, 1997) recommended the collection of the following data on all fire apparatus: (a) complete description of the apparatus including performance capabilities, (b) year of manufacture and current age, (c) mileage, (d) unit activity levels, and (e) total maintenance costs including parts and labor. Cottet (1992) further recommended collecting data concerning operating costs, and performing an assessment of the ability of the apparatus to comply with federal safety and NFPA standards. The CFAI (1997) recommended the need to track station assignment, operational status, and miles traveled during the previous year. Furthermore, Brown (1992) recommended the collection of additional detailed information such as the vehicle identification number, dates and times of maintenance, name of mechanic performing repairs, and the make and model of parts used in repairs.

Analysis of Data to Support Apparatus Replacement Recommendations

Brown (1992) recommended that all data collected on fire apparatus should be arranged to accommodate statistical analysis. Peters (1995) recommended a matrix that could be used for justification/magnification of the need to replace apparatus. This matrix included an analysis of escalating maintenance costs, increased downtime, non-compliance with new standards, and the need to increase efficiency.

In 1992, Cottet suggested that the results of a community risk assessment could be useful in projecting future fire apparatus requirements and replacement needs. Peters (1995) also addressed the value of a community risk analysis in planning for the future and estimating the need for fire apparatus replacement based on changing performance demands or performance criteria. Peters also explained the importance of allowing citizen input when defining an acceptable level of fire protection for a given community. Cottet (1992) supported the importance of citizen input and warned that the development of replacement plans that include the purchase of state-of-the-art fire apparatus may be a wasted effort if taxpayers are not willing to pay the additional costs for such enhancements.

Presenting Fire Apparatus Replacement Needs

Cottet stressed the importance of carefully planning all formal presentations of need to elected officials, municipal leaders, and citizens. It was recommended that presentations (a) focus attention on the conditions that have precipitated the need for fire apparatus replacement, (b) include supporting data, (c) provide an overview of the service enhancements that will be realized by the purchase of new fire apparatus, (d) include an estimate of associated costs or savings, and (e) include a projection of the likely outcome if funding for fire apparatus replacement is not approved. It was also considered beneficial for fire administrators to be prepared to answer any possible questions that may be raised, and discuss the advantages and disadvantages of any alternatives that may be suggested by those in attendance at formal presentations.

Cottet suggested that efforts to obtain support for fire apparatus replacement can be bolstered by routinely educating elected officials and municipal leaders on the needs of their fire department. It was proposed that if these individuals better understand the issues that affect the useful life span of fire apparatus, they would be able to make informed decisions when formal requests for replacement funding are made. It was also noted that taxpayers can be educated about the needs of their fire department through meetings with civic organizations, or by developing positive relationships with members of the news media who can help carry the message about fire apparatus replacement needs to the public-at-large.

Alternatives for Extending the Useful Life Span of Fire Apparatus

Several articles in the fire service literature outlined the advantages and disadvantages of rehabilitation and refurbishment as alternatives for extending the useful life span of fire apparatus.

Craven (1995) distinguished the difference between apparatus rehabilitation and refurbishment. Rehabilitation was described as the restoration of a piece of fire apparatus to meet the standards to which it was originally constructed. In contrast, refurbishment was described as the improvement of the condition of existing apparatus to meet current standards.

Peters (1992) noted that some fire departments may consider rehabilitating or refurbishing an existing apparatus as opposed to purchasing a new unit when there is the (a) lack of sufficient funding for new apparatus purchases; (b) inability of large, modern apparatus to meet the size, weight, and maneuverability restrictions inherent in older urban communities; and (c) inability of the apparatus industry to produce a new cost-effective model of specialized fire apparatus for which the fire department has a specific need.

Craven (1995) stressed the importance of performing a cost analysis prior to investing funds in apparatus rehabilitation or refurbishment. The steps recommended for inclusion in an apparatus cost analysis consisted of (a) calculation of the present value of the apparatus, (b) estimation of the impact of rehabilitation on the useful life span of the apparatus, (c) comparison of maintenance and operating costs for existing apparatus with similar cost projections for new apparatus, (d) comparison of the purchase price of new apparatus with the estimated resale value of existing units, and (e) comparison of the estimated cost of refurbishing with the estimated cost of rehabilitating.

Peters (1992) discussed the importance of assessing the performance of existing apparatus when considering refurbishment or rehabilitating as alternatives. The issues recommended for inclusion in the performance assessment consisted of the ability to meet (a) departmental mission requirements and service demands over the next 5 to 10 years, (b) special performance requirements that would otherwise be difficult to reproduce in a new apparatus, and (c) federal safety and NFPA standards. An assessment of the ability of vendors to supply replacement parts for the vehicle to meet future maintenance requirements was also recommended.

Peters warned that “any refurbishment undertaken is only delaying the inevitable: the eventual replacement of the vehicle. Delaying the purchase could as much as double the price of replacement in the future, depending on the rate of inflation” (p. 50). Craven (1995) suggested that either process can be extremely expensive and may even be more costly than purchasing a new vehicle. Capitol Safety Systems (1991) suggested that rehabilitating existing fire apparatus may be neither practical nor cost effective for a fire department, due to changes in service demands, increase in fire apparatus performance requirements, and existence of new emergency vehicle technology.

Literature Review Summary

The literature review provided key insights into variables that affect the useful life span of fire apparatus, data collection and analysis methods to support fire apparatus replacement recommendations, and alternatives to fire apparatus replacement.

A preliminary review of fire service textbooks revealed that the useful life span of fire apparatus could vary due to differences in frequency and type of use, local environments and operating conditions, and preventive maintenance efforts. A further review of fire service textbooks and literature revealed numerous variables that may affect the useful life span and replacement intervals of fire apparatus. These variables included age, maintenance costs, performance testing, unplanned replacement, obsolescence, and non-compliance with safety and consensus standards. The writings of various authors (Capitol Safety Systems, 1991; CFAI, 1997; Craven, 1995; Peters, 1995) suggested a relationship between the variables of age, use, and maintenance costs.

The fire service literature stressed that fire apparatus replacement recommendations should be supported by an objective analysis of apparatus operating and maintenance data, community risks, and community needs. It was also noted that formal presentations of replacement needs should be carefully planned and attempts should be made in advance to educate elected officials, municipal leaders, and citizens about the needs of the fire department.

Several authors (Craven, 1995; Peters, 1992) examined the merits of rehabilitation and refurbishment as alternatives for extending the useful life span of fire apparatus. It was suggested that a fire department might pursue these alternatives when there is insufficient funding for a new vehicle or when a specific need exists for the performance features of an existing apparatus, which cannot be duplicated in a new vehicle. Despite the obvious benefits, it was noted that these alternatives only delay the inevitable replacement of an existing apparatus.

The works of the authors summarized in the literature review influenced this research project in various ways. First, the identification of variables that affect the useful life span of fire apparatus in addition to age, highlighted the need to examine variables that may affect the useful life span of NFPS fire apparatus. Second, the implied inadequacy of age as an exclusive criterion on which to base apparatus replacement decisions underscored the need to compare the planned replacement intervals of fire apparatus in Norfolk with the projected useful life span of existing units. Finally, the suggested variation in the useful life span of fire apparatus among localities illustrated the need to examine the fire apparatus replacement practices of other fire departments.

PROCEDURES

This research project employed a descriptive research methodology to (a) examine NFPS fire apparatus data on age, use, maintenance costs, and performance tests, (b) assess the operating condition and performance levels of existing NFPS fire apparatus, (c) compare the planned replacement intervals of the NFPS with the projected remaining life span of existing fire apparatus, and (d) examine the replacement practices of other local fire departments. The procedures use to complete this research included a literature review, a review of Norfolk City records, a survey of NFPS fire apparatus, and a survey of the fire apparatus practices of other local fire departments.

Literature Review

The literature review was initiated at the National Fire Academy's Learning Resource Center (LRC) during November 1998. The literature review was continued at the Virginia Beach Fire Department Training Center Library in Virginia Beach, Virginia and the author's personal library between December 1998 and February 1999.

The literature review targeted trade journals, magazines, and textbooks that contained information on fire apparatus replacement practices. Applicable sources were summarized and included in the Literature Review section of this report.

Review of Norfolk City Records

A review of Norfolk City records was conducted between February and March 1999. The records targeted by this review included city capital asset inventories, Norfolk Fleet Maintenance Facility vehicle records and billing reports, and VFIRS annual reports. Data were collected on apparatus age, unit activity, total mileage, and total maintenance costs for 1998. Mileage totals were rounded to the nearest mile, and maintenance costs were rounded to the nearest dollar. In addition, the fire apparatus records maintained by the NFPS were examined for current fire pump and aerial ladder service test certificates and any other information that would be useful to this research project.

The raw data collected as a result of the records review were entered into Microsoft Excel 97© spreadsheets, and the calculation of annual mileage, maintenance costs per mile, mean averages, and standard deviations were performed. The resulting data and statistics were organized into tables and frequency distributions for further analysis. A series of histograms was also developed to illustrate the mean averages of age, use, and maintenance costs for each type of first-line and reserve apparatus, and illustrate the variations in age, use, and maintenance costs of all fire apparatus in the NFPS fleet.

NFPS Fire Apparatus Survey

An opinion survey was developed to assess the operating conditions and performance levels of NFPS fire apparatus. The survey was also designed to obtain projections of the remaining useful life span of these units.

The survey consisted of three parts: assessment of operating condition (Part I), assessment of performance level (Part II), and projection of remaining useful life span (Part III). Part I of the survey asked respondents to rate the condition of essential components, systems, and equipment of each apparatus on a scale of 1 *poor* to 5 *excellent*. The essential components, systems, and equipment addressed by the survey included (a) cab assembly, (b) body assembly, (c) drive train, (d) braking system, (e) suspension system, (f) electrical system, (g) fire pump, (h) foam proportioning system, (i) booster tank, (j) aerial device, and (k) ancillary systems and equipment. Part II of the survey asked respondents to answer yes or no questions concerning apparatus performance reliability, and the ability of the apparatus to meet the mission requirements of the NFPS. Part III of the survey asked respondents to project the remaining useful life span of the apparatus, based on a five-year incremental scale that ranged from less than one year to 25 years.

Draft copies of the apparatus survey were field tested by several personnel assigned to the 1st Battalion B-shift. These personnel recommended various changes, which resulted in the editing of several questions to eliminate ambiguity. A total of 35 final copies of the survey were distributed through interdepartmental mail during March 1999 to all NFPS fire apparatus operators assigned to B-shift. All 35 copies of the survey were completed and returned, which accounted for a response rate of 100%.

The responses from the fire apparatus surveys were entered into Microsoft Excel 97© spreadsheets, and mean averages and standard deviations of the ratings for the essential components, systems, and equipment categories were calculated. The resulting data and statistics were organized into tables and frequency distributions for further analysis. A series of histograms was developed to illustrate the variations in responses for operating condition, performance level, and projection of remaining useful life span.

Local Fire Department Survey

A survey was developed to collect information about the fire apparatus replacement practices of other local fire departments. The survey asked open-ended questions about the size of the locality and estimated population, the number of first-line and reserve fire apparatus, and the variables that were factored into fire apparatus replacement decisions. The survey was modeled after a similar survey that was conducted by the author during May of 1998.

Surveys were mailed to the fire departments of the eight cities and two counties within the Tidewater Metropolitan Area of Virginia during April 1999. The fire departments in the Tidewater area were selected to participate in the survey because Norfolk City leaders frequently perform comparative analysis of the practices of other local governments in many policy and program areas. Completed surveys were received from the Cities of Chesapeake, Hampton, Newport News, Portsmouth, and Virginia Beach, and the County of York, which accounted for a response rate of 60%.

Quantitative survey responses were organized and listed in several tables. Qualitative responses were summarized and included in the Results section of this report.

Assumptions

The procedures employed in this research project were based on four basic assumptions. First, it was assumed that all authors referenced in the literature review performed objective and unbiased research. Second, it was assumed that data obtained from Norfolk City records were accurate and current. Third, it was assumed that each survey respondent answered all questions fairly and objectively. Fourth, it was assumed that survey respondents did not discuss issues related to operating condition, performance levels, or the useful life span of apparatus with each other prior to completing the surveys.

Limitations

The limitations that affected this research project included time, the absence of critical apparatus data, the effects of warranty service coverage on maintenance costs, and the selection of NFPS operators for the fire apparatus survey.

The six-month time limit imposed by the National Fire Academy for the completion of Executive Fire Officer applied research projects, did not allow a more comprehensive literature review. The time limit also prohibited a survey of the fire apparatus replacement practices of other fire departments outside the Tidewater Metropolitan Area.

An initial review of Norfolk Fleet Maintenance records from 1994 to 1998 revealed a serious gap in mileage data for NFPS fire apparatus. Mileage totals for some apparatus were recorded inaccurately, whereas the mileage totals of other apparatus were missing altogether. As a result, it was necessary to augment the fleet maintenance data with the mileage totals tracked by the NFPS for 1998. This narrowed the focus of data analysis to a single year, and prohibited the use of a time series analysis to identify any trends that may have existed during previous years. Other gaps in critical apparatus data included unit activity of reserve apparatus and downtime for maintenance and repairs.

Another data quality issue was the effect of warranty service coverage on total maintenance costs. Two-year manufacturer’s general warranties and service agreements cover all new fire apparatus purchased by the NFPS. During the warranty period, all defects in materials and workmanship are repaired by factory authorized service technicians at no cost to the city. Therefore, the maintenance costs for apparatus that were less than two years of age were underreported in the fleet maintenance records, which impacted the calculations of mean average and standard deviation.

The selection of NFPS fire apparatus operators to participate in the fire apparatus survey was limited to those individuals assigned to B-shift. This action was taken to ensure control over survey distribution and return. Because a non-randomized selection process was employed, the results of the fire apparatus survey cannot be considered a reflection of the opinions of the entire population of NFPS fire apparatus operators with any degree of certainty. Nevertheless, the results of this survey provided information that was essential to this research project.

RESULTS

1. What are the ages, mileage totals, unit activity levels, maintenance costs, and performance test results of NFPS fire apparatus?

The review of Norfolk City records revealed that the NFPS operated a fleet of 35 fire apparatus including 14 first-line engines, 7 first-line ladders, 2 first-line squads, 7 reserve engines, 3 reserve ladders, and 2 reserve squads. A complete inventory of NFPS apparatus is listed in Table B1.

Age

The ages of fire apparatus in the NFPS fleet ranged from less than 1 year to 35 years. As shown in Table B2, the age ranges of first-line apparatus were (a) engines--less than 1 year to 12 years; (b) ladders--less than 1 year to 24 years; and (c) squads--three to eight years. The age ranges of reserve apparatus were (a) engines--13 to 29 years; (b) ladders--17 to 35 years; and (c) squads--16 to 18 years.

As shown in Table B3 and illustrated in Figure C1, the mean ages of first-line apparatus were (a) engines--six years; (b) ladders--10 years; and (c) squads--six years. The mean ages of reserve apparatus were (a) engines--25 years; (b) ladders--25 years; and (c) squads--17 years.

As illustrated in Figure C2, the ages of 34.3% of the fire apparatus in the NFPS fleet ranged zero to five years of age, 20.0% ranged 6 to 10 years of age, 14.3% ranged 16 to 20 years of age, 11.4% ranged 26 to 30 years of age, 8.6% ranged 11 to 15 years of age, 8.6% ranged 21 to 25 years of age, and 2.9% ranged 31 to 35 years of age.

Total Mileage

The mileage totals of fire apparatus in the NFPS fleet ranged from 3,218.0 to 177,223.0 miles. As shown in Table B2, the total mileage ranges of first-line apparatus were (a) engines--3,218.0 to 99,218.0 miles; (b) ladders--5,560.0 to 72,984.0 miles; and (c) squads--84,000.0 to 138,517.0 miles. The mileage ranges of reserve apparatus were (a) engines--86,091.0 to 177,223.0 miles; (b) ladders--34,050.0 to 141,137.0 miles; and (c) squads--142,400.0 to 157,870.0 miles.

As shown in Table B4 and illustrated in Figure C3, the mean mileage totals of first-line apparatus were (a) engines--41,522.0 miles; (b) ladders--32,141.0 miles; and (c) squads--111,256.0 miles. The mean mileage totals of reserve apparatus were (a) engines--116,167.0 miles; (b) ladders--81,356.0 miles; and (c) squads--150,135.0 miles.

As illustrated in Figure C4, 28.6% of the NFPS fleet ranged 0 to 25,000 miles, 20.0% ranged 75,001 to 100,000 miles, 17.1% ranged 25,001 to 50,000 miles, 14.3% ranged 50,001 to 75,000 miles, 11.4% ranged 125,001 to 150,000 miles, 2.9% ranged 100,001 to 125,000 miles, 2.9% ranged 150,001 to 175,000 miles, and 2.9% ranged 175,001 to 200,000 miles.

Annual Mileage

The annual mileage accrued during 1998 by fire apparatus in the NFPS fleet ranged from 116.0 to 20,483.0 miles. As shown in Table B2, the annual mileage ranges of first-line apparatus were (a) engines--3,715.0 to 10,790.0 miles; (b) ladders--1,882.0 to 6,830.0 miles; and (c) squads--18,443.0 to 20,483.0 miles. The annual mileage ranges of reserve apparatus were (a) engines--116.0 to 14,190.0 miles; (b) ladders--209.0 to 2,988.0 miles; and (c) squads--237.0 to 1,925.0 miles.

As shown in Table B5 and illustrated in Figure C5, the mean mileage accrued by first-line apparatus was (a) engines--7,251.0 miles; (b) ladders--4,846.0 miles; and (c) squads--19,463.0 miles. The mean mileage accrued by reserve apparatus was (a) engines-4,449.0 miles; (b) ladders--1,362.0 miles; and (c) squads--1,081.0 miles.

As illustrated in Figure C6, 53.1% of the NFPS fleet accrued 0 to 5,000 miles, 34.4% accrued 5,001 to 10,000 miles, 6.3% accrued 10,001 to 15,000 miles, 3.1% accrued 15,001 to 20,000 miles, and 3.1% accrued 20,001 to 25,000 miles.

Unit Activity

The unit activity levels of fire apparatus in the NFPS fleet for 1998 ranged from 263 to 1,929 emergency responses. As shown in Table B2, the unit activity level ranges of first-line apparatus were (a) engines--702 to 1,929 responses; (b) ladders--263 to 887 responses; and (c) squads--1,678 to 1,829 responses. The unit activity levels of reserve apparatus were not reported.

As shown in Table B6 and illustrated in Figure C7, the mean unit activity levels of NFPS first-line apparatus were (a) engines--1,273 responses; (b) ladders--608 responses; and (c) squads--1,754 responses.

As illustrated in Figure C8, 34.8% of the NFPS fleet answered 501 to 1,000 emergency calls, 30.4% answered 1,001 to 1,500 emergency calls, 26.1% answered 1,501 to 2,000 emergency calls, and 8.7% answered 0 to 500 emergency calls.

Total Maintenance Costs.

The total maintenance costs for 1998 of fire apparatus in the NFPS fleet ranged from $10.00 to $24,000.00. As shown in Table B2, the maintenance cost ranges of first-line apparatus were (a) engines--$10.00 to $11,659.00; (b) ladders--$4,450.00 to $24,000.00; and (c) squads--$16,462.00 to $18, 035.00. The maintenance cost ranges of reserve apparatus were (a) engines--$1,663.00 to $13,161.00; (b) ladders--$5,273.00 to $8,211.00; and (c) squads--$1,146.00 to $2,192.00.

As shown in Table B7 and illustrated in Figure C9, the mean total maintenance costs of NFPS first-line fire apparatus were (a) engines--$5,616.14; (b) ladders--$9,651.43; and (c) squads--$17,248.50. The mean total maintenance costs of reserve fire apparatus were (a) engines--$5,802.29; (b) ladders--$7,075.33; and (c) squads--$1,669.00.

As shown in Figure C10, 45.7% of the total maintenance costs of NFPS fire apparatus ranged from $0.00 to $5,000.00, 31.4% ranged from $5,001.00 to $10,000.00, 11.4% ranged from $10,001.00 to $15,000.00, 8.6% ranged from $15,001.00 to $20,000.00, and 2.9% ranged from $20,001.00 to $25,000.00.

Maintenance Costs per mile

The maintenance costs per mile for 1998 of fire apparatus in the NFPS fleet ranged from $.25 to $37.04. As shown in Table B2, the maintenance cost per mile ranges of first-line apparatus were (a) engines--$.25 to $2.38; (b) ladders--$.66 to $12.75; and (c) squads--$.80 to $.98. The maintenance cost per mile ranges of reserve apparatus were (a) engines--$.32 to $14.34; (b) ladders--$2.75 to $37.04; and (c) squads--$1.14 to $4.84.

As shown in Table B8 and illustrated in Figure C11, the mean maintenance costs per mile of NFPS first-line fire apparatus were (a) engines--$.99; (b) ladders--$3.50; and (c) squads--$.89.

The mean maintenance costs per mile of reserve fire apparatus were (a) engines--$3.41; (b) ladders--$15.24; and (c) squads--$2.99.

As shown in Figure C12, 42.9% of the maintenance costs per mile of NFPS fire apparatus ranged from $0.00 to $1.00, 25.7% ranged from $1.01.00 to $2.00, 14.3% ranged from $2.01.00 to $3.00, 11.4% ranged from $5.01 and beyond, 2.9% ranged from $3.01 to $4.00, and 2.9% ranged from $4.01 to $5.00.

<u>Performance Test Results</u>

The review of NFPS fire apparatus records revealed that only two of the apparatus equipped with fire pumps (9.1%) had successfully completed performance tests within the past year in accordance with NFPA 1911. In addition, only two of the apparatus equipped with aerial devices (14.3%) had successfully completed performance tests within the past year in accordance with NFPA 1914. The findings of the NFPS fire apparatus records review are shown in Table B9 and illustrated in Figure C13.

2. What is the operating condition and performance level of each fire apparatus in the NFPS fleet, as judged by fire apparatus operators?

<u>Essential Components</u>

The ratings of the condition of the essential components of fire apparatus in the NFPS fleet ranged from poor to excellent in each of the categories of cab assembly, body assembly, drive train, brake system, suspension system, and electrical system. The results of the fire apparatus survey as related to essential components, are shown in Table B10 and illustrated in Figure C14.

The ratings of the condition of specific essential components were (a) cab assemblies--57.1% rated good to excellent, 42.8% rated fair to poor; (b) body assemblies--51.4% rated fair to poor, 48.6% rated good to excellent; (c) drive trains--68.5% rated good to excellent, 31.4% rated fair to poor; (d) braking systems--57.1% rated good to excellent, 48.6% rated fair to poor; (e) suspension systems--51.4% rated good to excellent, 48.6% rated fair to poor; and (f) electrical systems 51.4% rated fair to poor, 48.6% rated good to excellent.

Systems and Equipment

The ratings of the operating condition of systems and equipment ranged from poor to excellent in each of the categories of fire pump booster tank, aerial device, and ancillary systems, and from fair to excellent in the category of foam proportioning system. The results of the fire apparatus survey, as related to systems and equipment, are shown in Table B11 and illustrated in Figure C15.

The ratings of the condition of specific systems and equipment were (a) fire pumps--68.2% rated good to excellent, 31.8% rated fair to poor; (b) foam systems--85.8% good to excellent, 14.3% rated fair; (c) booster tanks--63.7% rated good to excellent, 36.3% rated fair to poor; (d) aerial devices--57.1% rated fair to poor, 42.8% rated good to excellent; and (e) ancillary systems--87.6% rated good to excellent, 12.6% rated fair to poor.

Performance Levels.

As shown in Table B12 and illustrated in Figure C16, a majority of NFPS operators (60.0%) answered affirmatively when asked if the existing apparatus was consistently reliable at emergency incidents; 14 operators (40.0%) answered negatively. A slight majority of NFPS operators (51.4%) answered affirmatively when asked if the performance capabilities of the existing apparatus met the mission requirements of the NFPS; 17 operators (48.6%) answered negatively.

3. How do the planned replacement intervals of the NFPS compare to the remaining useful life spans of fire apparatus, as projected by fire apparatus operators?

The remaining life spans of fire apparatus in accordance with the NFPS planned replacement intervals, and the apparatus operator projections of remaining useful life spans both ranged from less than 1 year to 20 years. As shown in Table B13 and illustrated in Figure C17, the remaining life span of 31.4% of the apparatus in the NFPS fleet was estimated at 16 to 20 years, 25.7% was estimated at less than one year, 14.3% was estimated at one to five years, 14.3% was estimated at 6 to 10 years, and 14.3% was estimated at 11 to 15 years. Conversely, fire apparatus operators projected that the remaining useful life span of 34.3% of the NFPS fleet was less than one year, 25.7% was one to five years, 22.9% was 6 to 10 years, 14.3% was 11 to 15 years, and 2.9% was 16 to 20 years.

4. What variables do other local fire departments examine when assessing fire apparatus for replacement?

The Chesapeake, Hampton, Newport News and York County fire departments all reported that a combination of variables were referenced when assessing fire apparatus for replacement. These variables included age, mileage, maintenance costs, and operating condition. The Portsmouth Fire Department reported that age was referenced in replacement decisions, and that apparatus were typically replaced after 20 years of service. The Newport News Fire Department reported extending the life span of some existing fire apparatus through refurbishment.

A notable finding of the survey was the comprehensive assessment that all city vehicles receive as part of Virginia Beach's vehicle replacement program. This program involves the calculation of a replacement score for each vehicle in the city's fleet, based on the sum of individual scores for age, usage, and condition. The data for these calculations are obtained from computerized vehicle maintenance records and work orders.

The age of a vehicle is scored by assigning one point for each month beyond the date on which the vehicle was purchased. The usage score is reached by assigning 1 point for each 1,000 miles traveled or 3.5 points for each 100 hours of use, whichever is higher. The condition of a vehicle is scored on a scale of 0, 2, or 4, in accordance with criteria for each of the five categories including the body, interior, installed functional apparatus, maintenance/repair cost, and mission fulfillment. The sum of the scores for each category is then multiplied by a factor of 12 to obtain the condition score.

The overall vehicle score is then compared to the maximum score for the associated vehicle/equipment category as established by the American Public Works Association (APWA). If the overall score exceeds the limit established for the respective APWA category, the vehicle is recommended for disposal. The categories and associated maximum scores are (a) sedans, station wagons, and jeeps--162 points; (b) motorcycles and scooters--110 points; (c) light trucks--196 points; (d) medium to heavy duty trucks and refuse trucks--220 points; (e) fire apparatus--225 points; (f) heavy duty trucks and towed equipment--192 points; and (g) special purpose equipment such as boats and trailers--192 points.

DISCUSSION

The results of the Norfolk City records review revealed various practices of both the NFPS and the Norfolk Fleet Maintenance Facility that are incongruent with the recommendations of others in the literature review. These practices include (a) exceeding useful life span limitations for fire apparatus, (b) failure to perform regular apparatus performance testing, and (c) omission of critical data from apparatus records.

The fire apparatus life span limitation of 25 years, as recommended by the NFPA and supported by Peters (1994), was exceeded 1 to 10 years by five units. Although these units are classified as reserves, some are pressed into service on a regular basis when newer first-line apparatus are taken out of service for training, preventive maintenance, or repairs. This practice is averse to the warnings of Peters (1995) and Peterson (1994) about the potential unreliability of older apparatus and the risk of assigning such apparatus to front-line emergency service. The number of negative responses from fire apparatus operators substantiated these concerns, when asked if reserve apparatus were consistently reliable at emergency incidents. Although the total number of apparatus in the NFPS fleet that are beyond 25 years of age has been significantly reduced since 1993, it will likely be several more years before all apparatus in this age range are replaced.

Peters (1994) regarded regular performance testing as an essential element in ensuring that adequate performance levels are maintained. In the absence of a regular performance-testing program, the NFPS cannot be assured that apparatus equipped with fire pumps and aerial devices will perform safely and reliably at emergency incidents. Despite the recent approval of funding for the testing of aerial devices during Fiscal Year 2000, the testing of fire pumps remains unfunded.

The works of various authors (Brown, 1992; Cottet, 1992; CFAI, 1997) outlined a host of data that should be collected on all fire apparatus. Cottet (1992) addressed the use of this data to support fire apparatus replacement recommendations. The omission of critical information from Norfolk's apparatus records such as operating costs, mileage totals, downtime, and unit activity levels for reserve apparatus, minimizes both the quantity and quality of data with which to support replacement recommendations.

The results of the analysis of NFPS fire apparatus data substantiated the research of others in the areas of (a) the importance of regular fire apparatus replacement to avoid multiple purchases, (b) the value of quantifying maintenance costs in relation to apparatus use, and (c) the need to examine fire apparatus data by unit type. The significance of implied relationships between the variables that affect the useful life span of fire apparatus could neither be confirmed nor rejected, given the statistical methods chosen for the analysis of NFPS fire apparatus data.

The importance of planning for regular apparatus replacement, as noted by Peters (1994) and Peterson (1995), was supported by the analysis of NFPS apparatus age intervals. The results of this analysis showed that a relatively large number of NFPS fire apparatus (34.3%) were purchased within the past five years. As these vehicles become due for replacement during later years, it is conceivable that the NFPS will experience the need to purchase multiple units within a short time frame if the practice of regular replacement is not continued.

The research performed by Craven (1995) addressed the value of examining total operating and maintenance costs on a cost per mile basis to measure operational efficiency and assess the remaining useful life span of fire apparatus. This research was supported by the results of the data analysis, which demonstrated that apparatus with low total maintenance costs might not be considered cost-effective to operate when such costs are converted to a cost per mile format. It is conceivable that the calculation of maintenance costs per mile may prove to be useful to the NFPS in the future, as a tool for measuring fire apparatus operational efficiency and determining useful life spans for fire apparatus.

The variations in use and maintenance cost data between first-line and reserve apparatus illustrated the patterns of use and maintenance requirements that are inherent to different types of units. Because of these differences, future analysis of apparatus data should be stratified by unit type.

The results of the fire apparatus survey showed that all reserve apparatus and some first-line apparatus in the NFPS fleet may be obsolete and incapable of meeting the mission requirements of the department. The respondents to this survey rated the electrical systems, body assemblies, and aerial devices of many apparatus as being in fair to poor condition. In addition, the respondents agreed that all reserve apparatus and some first-line apparatus in the NFPS fleet were unreliable at emergency incidents and did not meet the current mission requirements of the department. The writings of various authors (Craven, 1995; Peters, 1995; Senter, 1998) suggested that fire apparatus may be considered obsolete for a number of reasons including (a) insufficient compartment space or weight ratings to accommodate the storage of modern emergency service equipment, (b) inadequate twelve-volt electrical systems for meeting the demands of emergency lighting and air conditioning systems, and (c) outdated technology. It is possible that apparatus operators considered certain NFPS apparatus to be obsolete on the basis of these very issues, as is reflected in their responses.

The results of the comparison of NFPS planned replacement intervals with the remaining life spans of existing fire apparatus as projected by fire apparatus operators, appear to indicate that the planned replacement intervals may not be on target. Given the projections of remaining life spans, and the less than acceptable ratings of operating conditions and performance levels of many existing apparatus, it is likely that more units will be in need of replacement over the next ten years than originally planned.

The survey results of the fire apparatus replacement practices of other fire departments in the Tidewater Metropolitan Area showed that most departments examined multiple variables when evaluating fire apparatus for replacement. The survey results also revealed a comprehensive vehicle assessment process used by the City of Virginia Beach that quantified vehicle replacement considerations, similar to the objective assessment processes discussed by Peters (1995). It is possible that the basic concepts of this process could be adopted by the NFPS to improve the objectivity of fire apparatus replacement decisions. Despite the success reported by one fire department in extending the life span of fire apparatus by refurbishing older units, the experience of the NFPS with similar alternatives has been less than satisfactory.

The results of this research project present various implications for the NFPS. First, the practice of following specific replacement intervals based exclusively on age is of limited value and should be discontinued as soon as possible. Second, steps should be taken to improve the collection and management of fire apparatus data so that statistical methods can be used to analyze historical data and forecast future replacement needs. Third, the operating conditions and performance levels of existing apparatus should be evaluated on a regular basis. Apparatus found to be inoperative or incapable of meeting standards of acceptable performance, should be promptly repaired or replaced.

RECOMMENDATIONS

The NFPS should develop a comprehensive data collection and management program to improve the quality and quantity of fire apparatus data for analysis and forecasting purposes. The data targeted by this program should include total mileage, annual mileage, annual unit activity (emergency responses), total engine hours, annual engine hours, annual maintenance costs, annual maintenance costs per mile, and downtime for maintenance and repairs. Additional information that should be collected on each apparatus includes unit number, city identification number, vehicle identification number, year of manufacture, name of manufacturer,

manufacturer's contract or shop order number, description of unit type, description of performance features of major systems and equipment, and date of last performance test. Furthermore, the time required to prepare bid specifications, conduct bid processes and award contracts, and construct and deliver fire apparatus should be routinely tracked.

Recommended collection methods for quantitative data include the review of fleet maintenance computerized vehicle records and maintenance billing reports, review of annual VFIRS data, and direct observation of vehicle odometers and hour meters. Recommended collection methods for qualitative data include the review of city capital asset inventories, fleet maintenance computerized vehicle records, construction specifications, and direct observation of apparatus specification plates.

Computerized and hard copy records should be established for each apparatus in the NFPS fleet. A suitable fleet management program can be purchased from a computer software vendor, or a database can be established using the existing Microsoft Access 97© software on NFPS computers. Hard copy files should be compiled to store printed copies of computerized records and any other documentation that is not suitable for computerized storage such as fire pump and aerial ladder test certificates.

The NFPS should develop a program to assess the operating condition of essential components, systems, and equipment of each apparatus on an annual basis. This program should also assess how well each apparatus meets the mission requirements of the department. Essential components that should be assessed include cab and body assemblies, the drive train, and braking, suspension, and electrical systems. Systems and equipment that should be assessed include fire pumps, foam systems, booster tanks, aerial devices, and ancillary systems such as on-board electrical generators, scene lighting systems, hydraulic and pneumatic rescue systems, mobile air compressors, and cascade systems. Mission requirements that should be assessed include the ability of the apparatus to effectively meet both service and operating demands.

A survey form should be developed to guide personnel through an objective assessment of specific items associated with the categories of essential components, systems, equipment, and mission suitability. The survey form should incorporate a five-point numerical rating scale ranging from 1 *lowest* to 5 *highest* for each item listed. Each apparatus should be surveyed by at least two personnel; one representing the NFPS and one representing the city's fleet maintenance facility. In the event the ratings of the two representatives differ by more than one point in any category, the representatives should discuss the disparity and search for a way to reach a consensus to close the gap between the scores. Final ratings should be obtained by calculating the average of the ratings for each item. The results of each survey should be referenced when evaluating apparatus for possible replacement.

An alternative to the five-point rating scale could be found through additional research of the processes employed by other localities such as Virginia Beach. The goal of any alternative chosen for the assessment of the operating condition of fire apparatus should be to maintain objectivity.

The NFPS should develop and implement a program to test the performance of apparatus equipped with fire pumps or aerial devices on an annual basis, or whenever major repairs are performed. This program should be in strict accordance with NFPA 1911, and NFPA 1914, titled. It is recommended that the NFPS contract with a bonded and certified third-party testing firm to perform all tests on aerial devices, due to the safety and liability issues involved. Qualified NFPS personnel may however conduct tests of fire pumps with a minimal investment in testing equipment.

The NFPS should perform a statistical analysis of the apparatus data resulting from the data collection and management program at the end of each fiscal year. This analysis should include descriptive statistics to measure central tendencies and variations in historical data, a time series analysis to identify any trends in historical data over a period of years, statistical process control calculations of data to establish parameters within which apparatus should conform, correlation analysis to test the relationships between the data, and a regression analysis to project possible changes in the data in the future if any relationships are found to be statistically significant. All analysis should focus on the stratification of apparatus data according to unit type such as first-line and reserve, engines, ladders, and squads.

Descriptive statistics should be used to describe apparatus data at any given time. Time series, correlation, and regression analysis should be used to support planning efforts for fire apparatus replacement. Statistical process control calculations of maintenance cost per mile data, along with the results of the operating condition assessments, should be examined to determine which apparatus should be recommended for replacement. With each passing year more data will be collected, which will improve the overall accuracy of replacement recommendations.

The NFPS should take prudent steps to extend the useful life span of fire apparatus wherever possible. One alternative that may prove to be beneficial is the regular rotation of fire apparatus between high and low running stations to distribute annual mileage and unit activity levels more evenly among first-line engines and ladders units. The strategic placement of specific types of apparatus, and the storage restrictions of older fire stations will of course limit this alternative.

Finally, the NFPS should continue to educate city management, city council members, civic leaders, and citizens on the fire apparatus needs of the department. Informative presentations should be developed using the media available to the department such as Microsoft PowerPoint 97© and digital photographs to illustrate the condition of fire apparatus and the obvious issues necessitating replacement. The need for performance features should be justified and the reasons for the high cost of purchasing fire apparatus should be explained.

Various recommendations are offered to those who are interested in performing additional research to improve fire apparatus life span projections in their fire departments. First, a more comprehensive search of available literature should be conducted, including a review of fleet management trade journals and magazines for information on the subject of useful life spans for public safety vehicles. Second, the analysis of fire apparatus data should be expanded to include observations from more than a single year whenever possible. This will allow the application of additional statistical analysis methods, which will improve the accuracy of results and strengthen conclusions. Third, use randomized selection methods and increase the number of fire apparatus operators selected to participate in fire apparatus surveys. This will help ensure results that more closely represent the opinions of the entire population of apparatus operators. Third, surveys of the fire apparatus practices of other fire departments should be expanded to include fire departments in major metropolitan cities such as New York, Chicago, Los Angeles, and Philadelphia. Many of these departments have personnel whose sole responsibility is the management of fire apparatus programs. Based on their experience, these personnel could potentially provide valuable information that would add to the body of knowledge on fire apparatus life span projections.

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Appendix A

Inter-Department Correspondence Sheet

TO:	All Operators of NFPS Fire Apparatus
FROM:	Edward L. Senter Jr. – Battalion Chief, 1st Battalion "B" Shift
COPIES TO:	File
SUBJECT:	Fire Apparatus Survey

[DATE CODE]

The purpose of this memo is to request your assistance with a survey I am currently conducting to assess the operating condition of the first-line and reserve fire apparatus in the NFPS fleet. The results of this survey will be included in an applied research project for the National Fire Academy as part of the Executive Fire Officer Program.

Attached to this memo is a user survey for the apparatus to which you are currently assigned. There may also be an additional survey attached for any reserve apparatus that is assigned to your station. Please complete the survey(s) and return them to me through inter-departmental mail by April 7, 1999.

If you have any questions, please feel free to contact me at Station 3, [PHONE NUMBER] or pager [PAGER NUMBER]. Your assistance with this survey is appreciated.

Edward L. Senter Jr.
Battalion Chief

Attachment

Appendix B

Table B1

Inventory of NFPS Fire Apparatus

Unit	I.D. No.	Manufacturer	Apparatus Type
E-01	9738	Emergency One	1500 GPM Fire Pumper
E-02	9735	Emergency One	1500 GPM Fire Pumper
E-04	9727	HME/Grumman	1500 GPM Fire Pumper
E-06	9703	Pierce	1500 GPM Fire Pumper/50’ Telescoping Boom
E-07	9728	HME/Grumman	1500 GPM Fire Pumper
E-08	9729	HME/Grumman	1500 GPM Fire Pumper
E-09	9733	Emergency One	1500 GPM Fire Pumper
E-10	9730	HME/Grumman	1500 GPM Fire Pumper
E-11	9741	Emergency One	1500 GPM Fire Pumper
E-12	9740	Emergency One	1500 GPM Fire Pumper
E-13	9713	Spartan/Thibault	1250 GPM Fire Pumper/50’ Telescoping Boom
E-14	9706	Spartan/Thibault	1250 GPM Fire Pumper/50’ Telescoping Boom
E-15	9734	Emergency One	1500 GPM Fire Pumper
E-16	9739	Emergency One	1500 GPM Fire Pumper
L-01	9731	Emergency One	95’ Aerial Platform (Rear Mount)
L-07	9737	Emergency One	100’ Aerial Ladder (Rear Mount)
L-08	9701	Pemfab/Emergency One	110’ Aerial Ladder/1500 GPM (Rear Mount)
L-09	9736	Emergency One	100’ Aerial Ladder (Rear Mount)
L-10	9756	American LaFrance	100’ Aerial Ladder (Tractor Drawn)
L-13	9761	Seagrave	100’ Aerial Ladder (Rear Mount)
L-14	9742	Emergency One	95’ Aerial Platform (Rear Mount)
S-01	9762	Spartan/Saulsbury	Heavy Rescue
S-02	9732	Emergency One	Heavy Rescue
RE-01	9702	Duplex/American LaFrance	1250 GPM Fire Pumper
RE-02	9711	American LaFrance	1000 GPM Fire Pumper
RE-03	9712	American LaFrance	1000 GPM Fire Pumper
RE-04	9714	American LaFrance	1000 GPM Fire Pumper
RE-05	9715	American LaFrance	1000 GPM Fire Pumper
RE-06	9721	American LaFrance	1000 GPM Fire Pumper
RE-07	9726	American LaFrance	1000 GPM Fire Pumper
RL-01	9754	American LaFrance	100’ Aerial Ladder (Tractor Drawn)
RL-02	9758	American LaFrance	100’ Aerial Ladder (Tractor Drawn)
RL-03	9760	Seagrave/ American LaFrance	100’ Aerial Ladder (Tractor Drawn)
RS-01	9778	GMC	Step Van
RS-02	9780	Chevrolet/Grumman	Step Van

Note. E = Engine Company; L = Ladder Company; S = Squad Company; RE = Reserve Engine; RL = Reserve Ladder; RS = Reserve Squad. I.D. No. = Norfolk Fleet Management Vehicle Number.

Appendix C

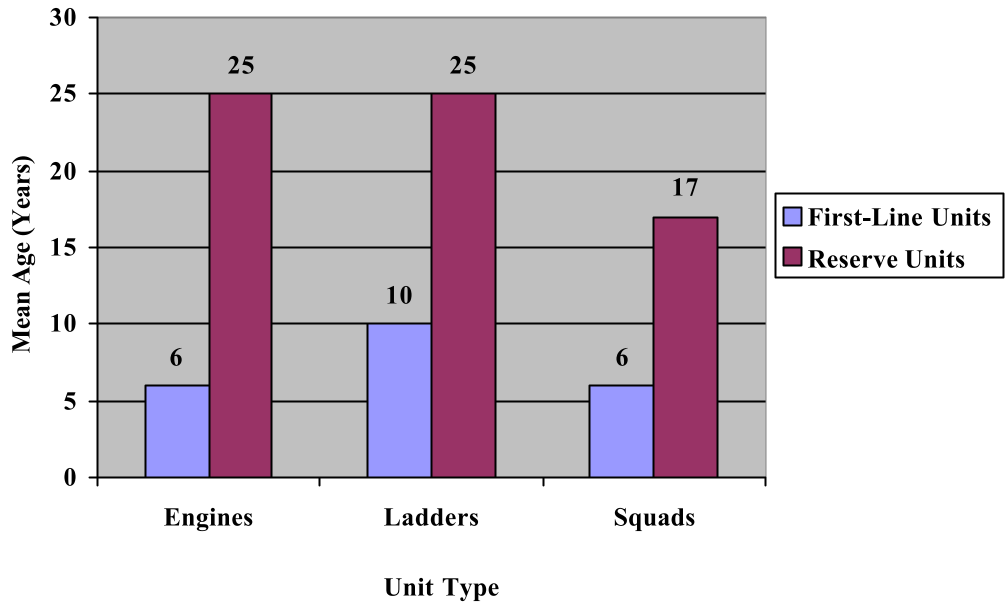

Figure C1. Mean ages of NFPS fire apparatus for 1998.

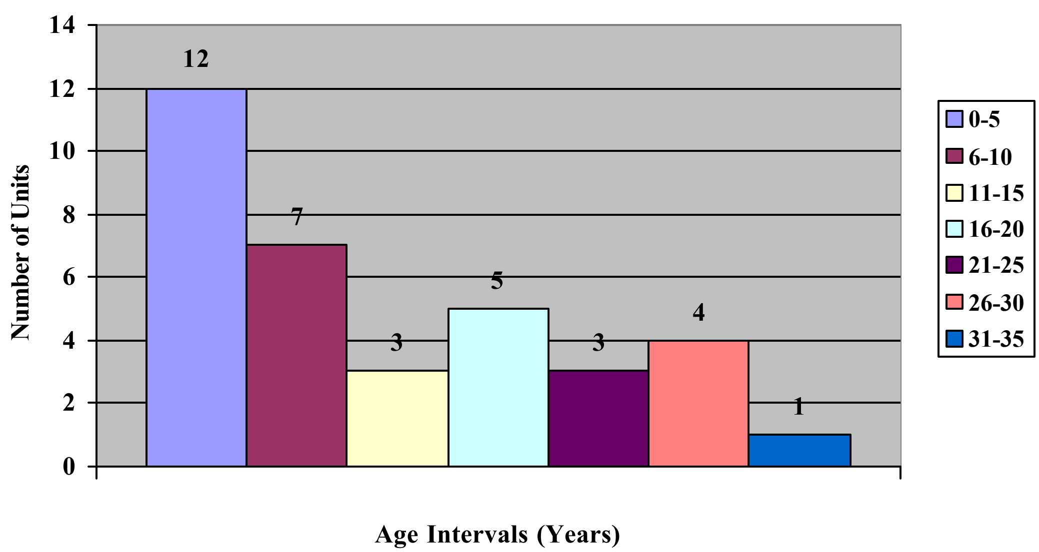

Figure C2. Age intervals of NFPS fire apparatus for 1998.

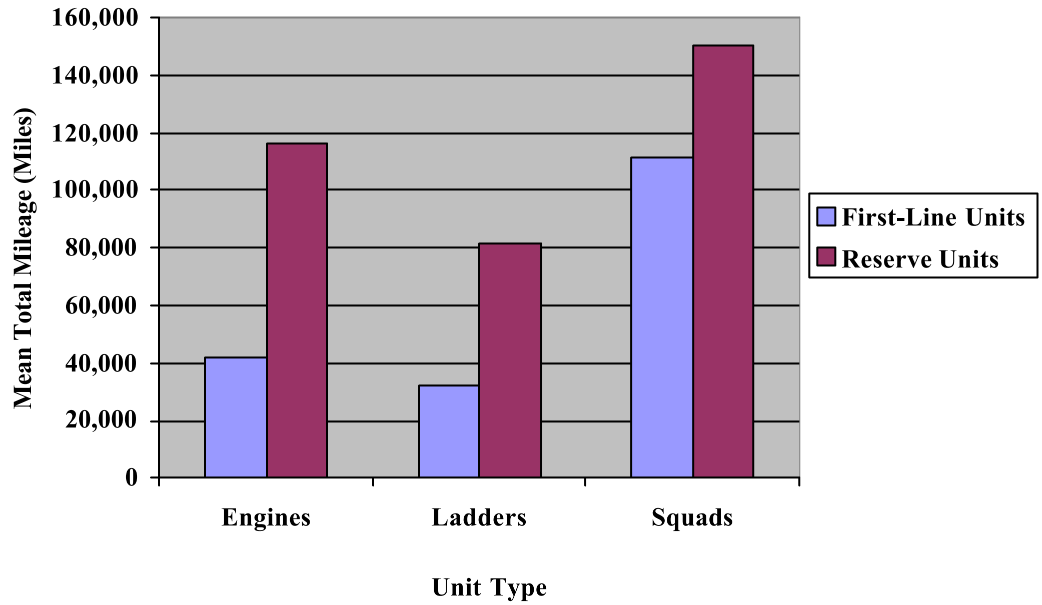

Figure C3. Mean total mileage of NFPS fire apparatus for 1998.

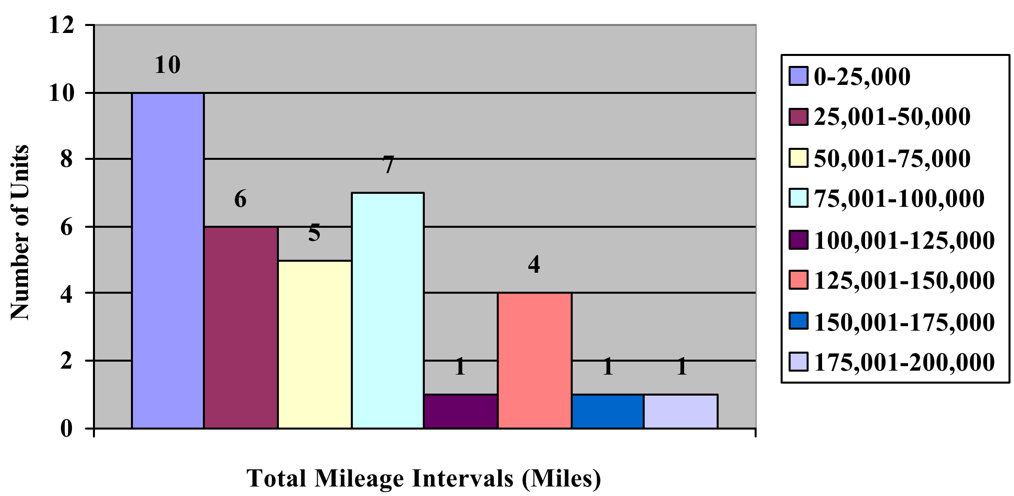

Figure C4. Total mileage intervals of NFPS fire apparatus for 1998.

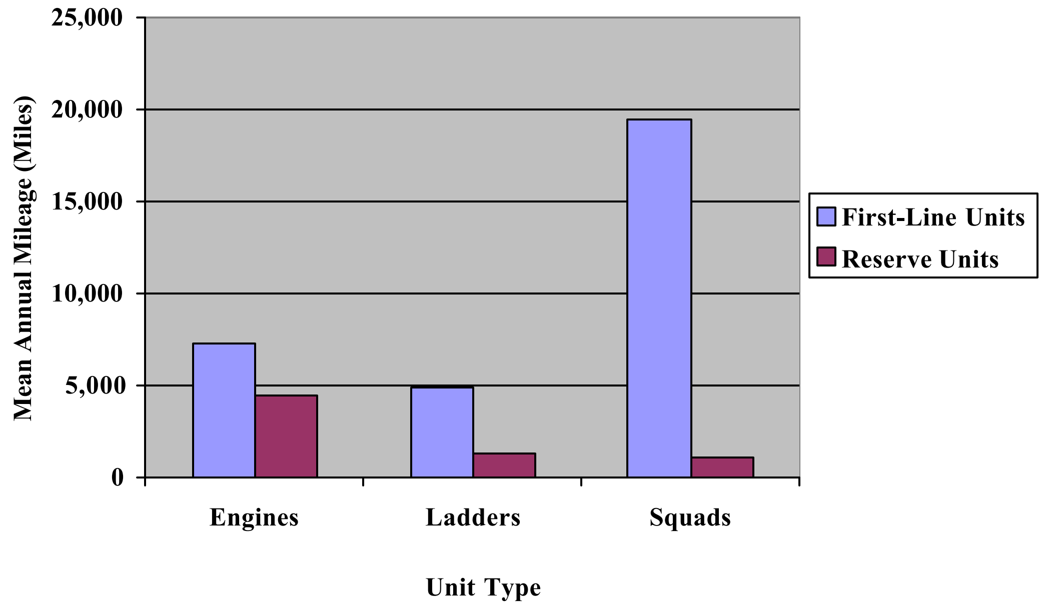

Figure C5. Mean annual mileage of NFPS fire apparatus for 1998.

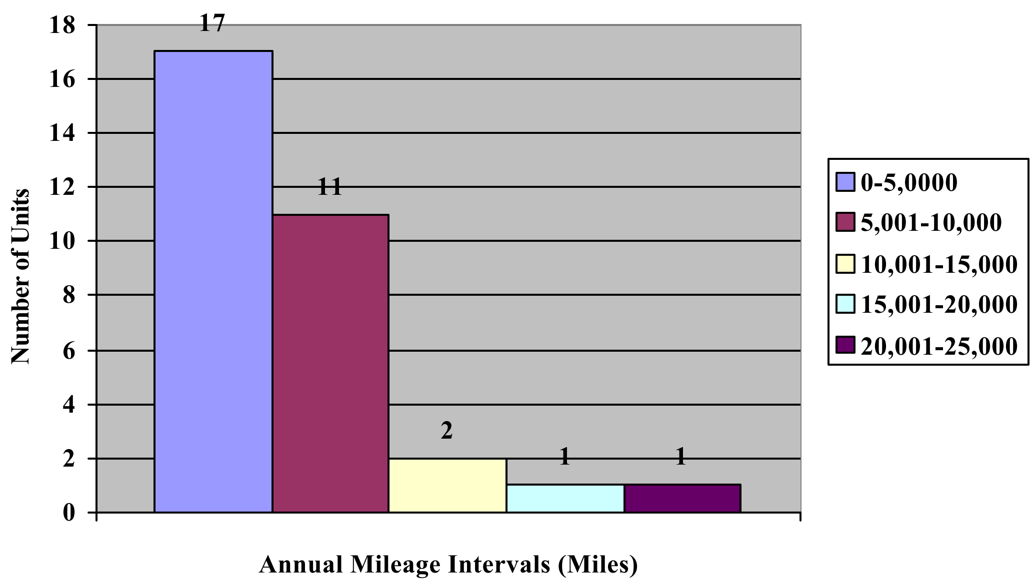

Figure C6. Annual mileage intervals of NFPS fire apparatus for 1998.

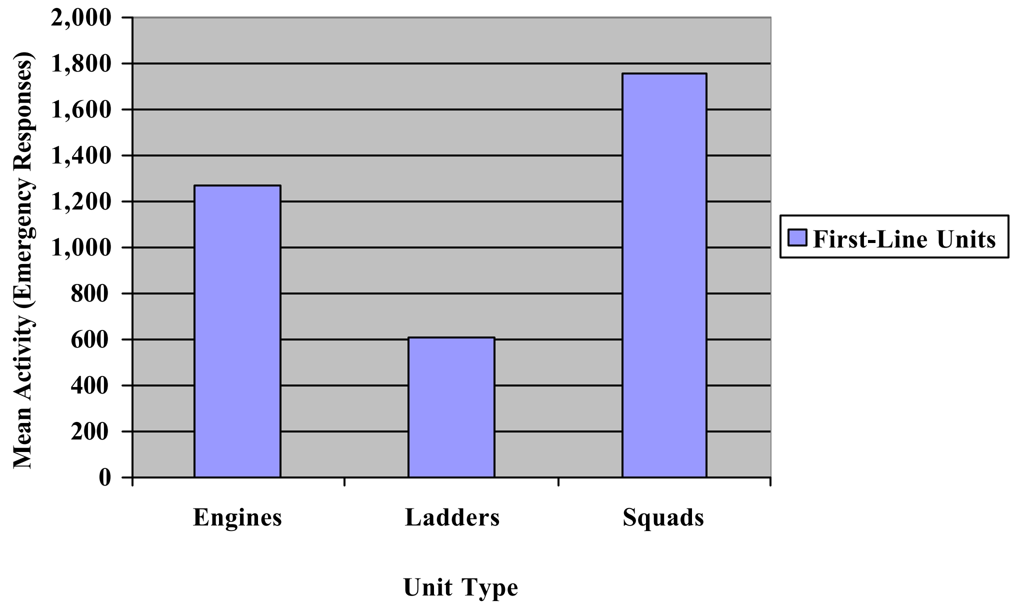

Figure C7. Mean unit activity of NFPS fire apparatus for 1998.

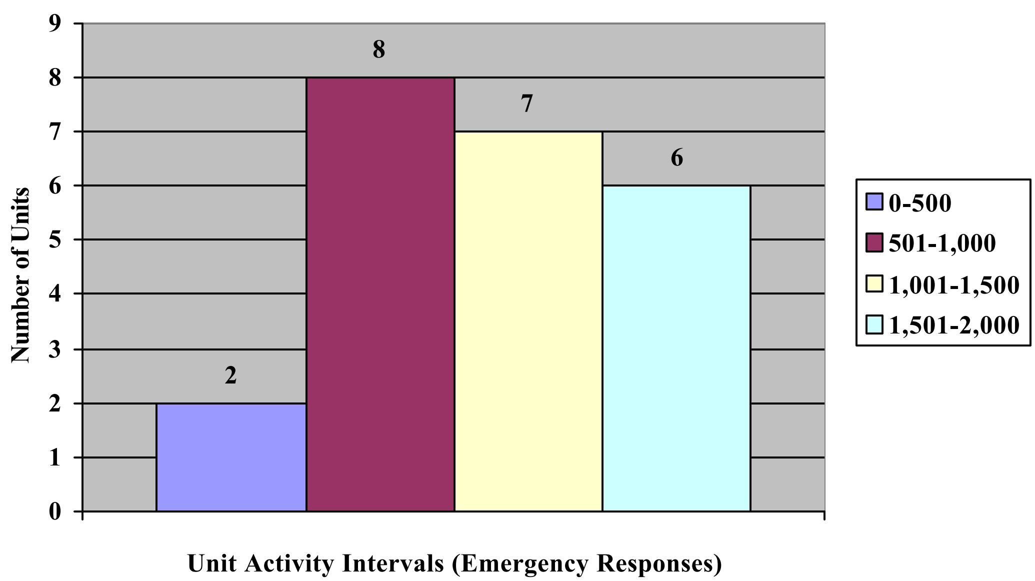

Figure C8. Unit activity level intervals of NFPS first-line apparatus for 1998.

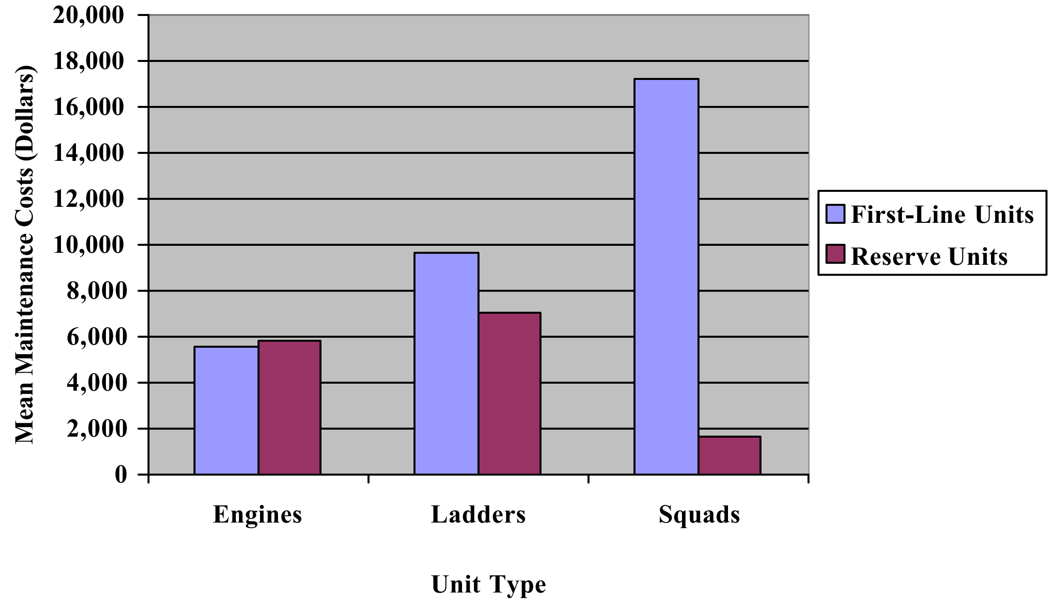

Figure C9. Mean total maintenance costs of NFPS fire apparatus for 1998.

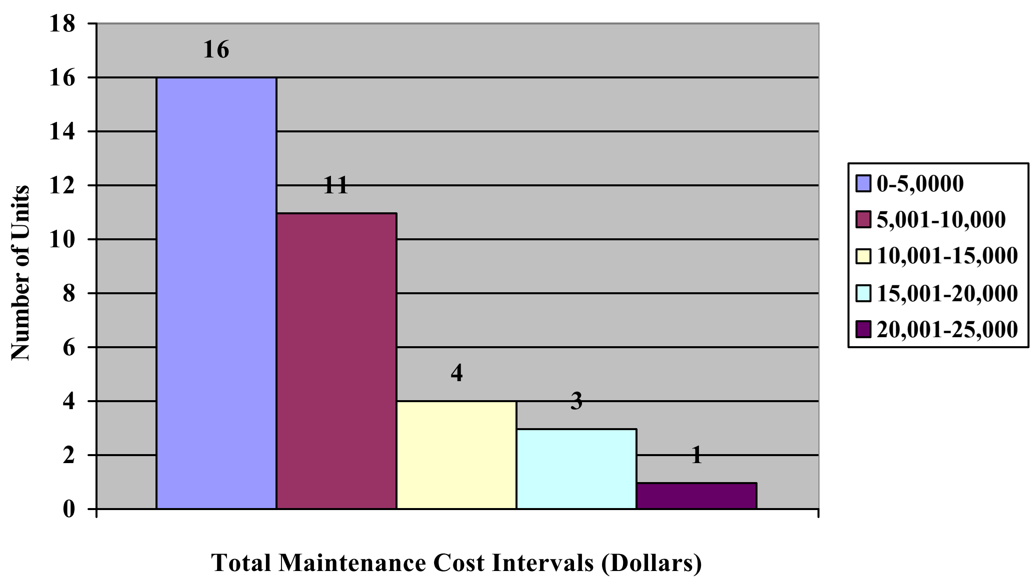

Figure C10. Total maintenance cost intervals of NFPS fire apparatus for 1998.

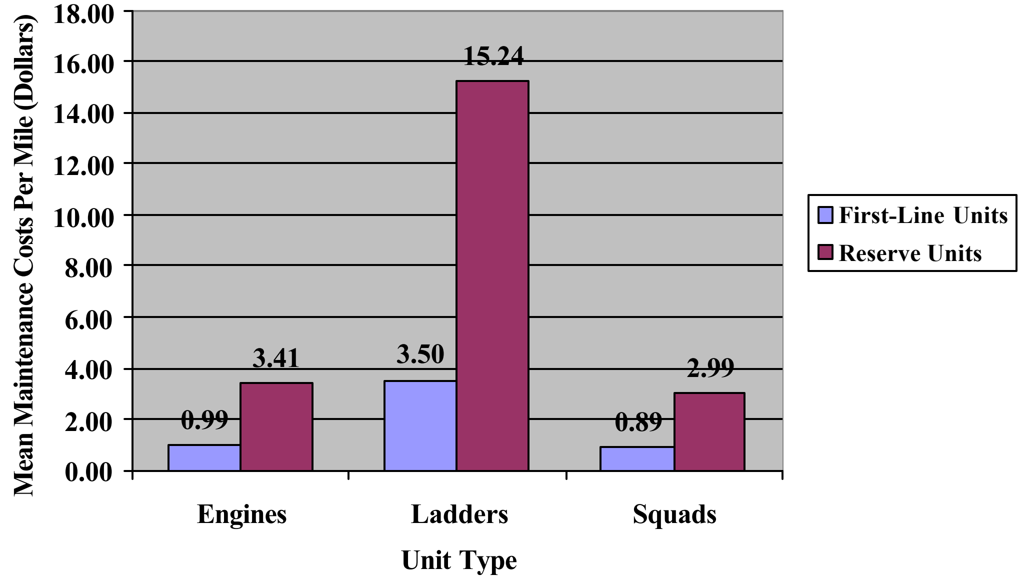

Figure C11. Mean maintenance costs per mile of NFPS fire apparatus for 1998.

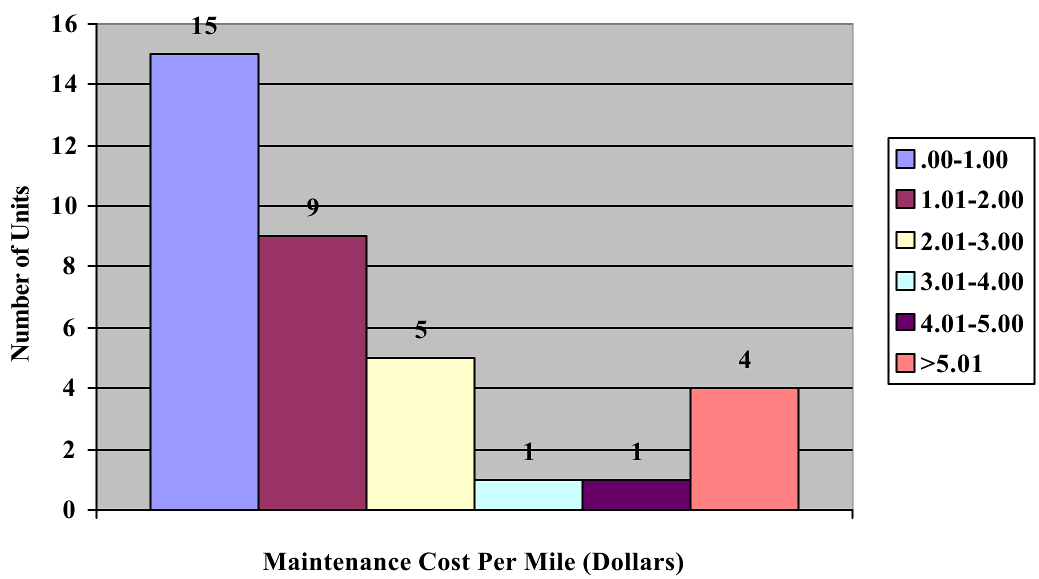

Figure C12. Maintenance cost per mile intervals of NFPS apparatus for 1998.

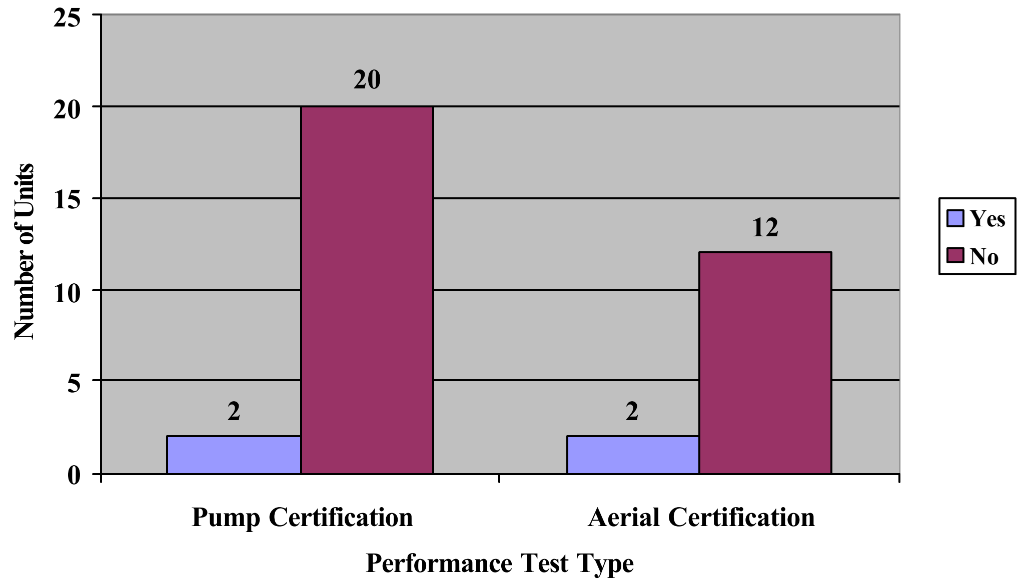

Figure C13. Performance test results of NFPS fire apparatus.

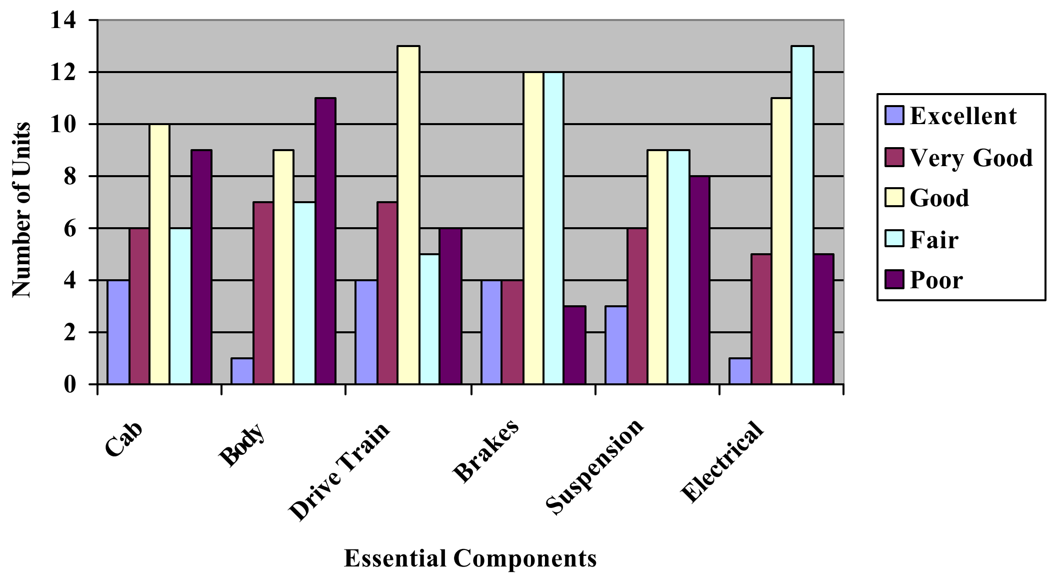

Figure C14. Ratings of the condition of the essential components of NFPS fire apparatus.

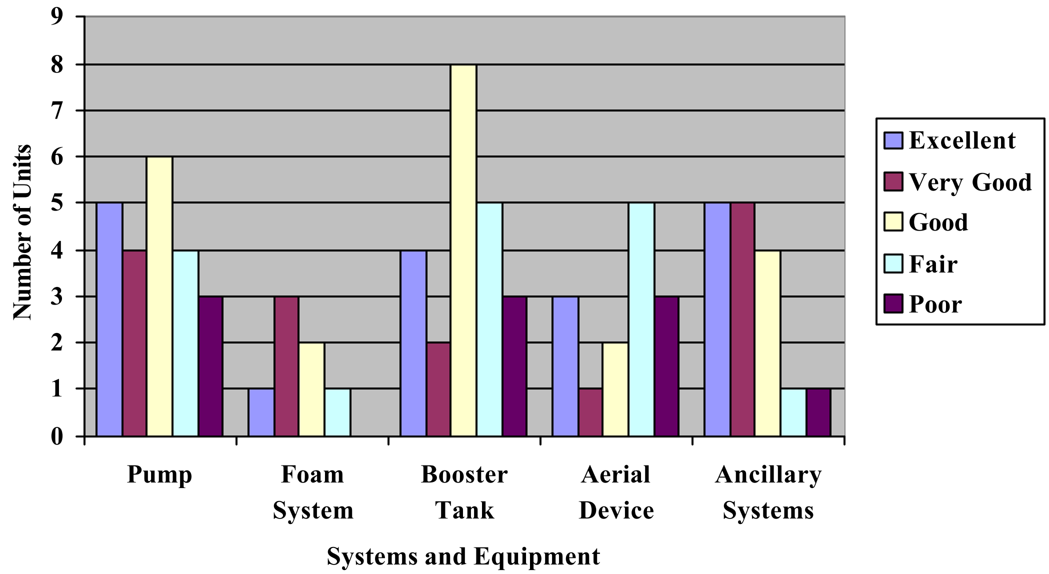

Figure C15. Ratings of the current condition of systems and equipment of NFPS apparatus.

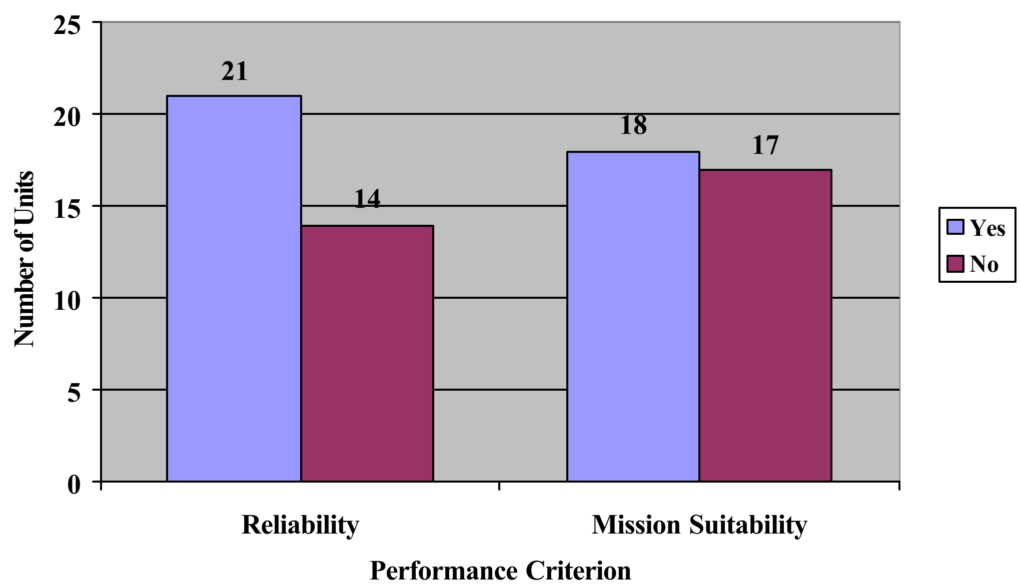

Figure C16. Ratings of the performance levels of NFPS fire apparatus.

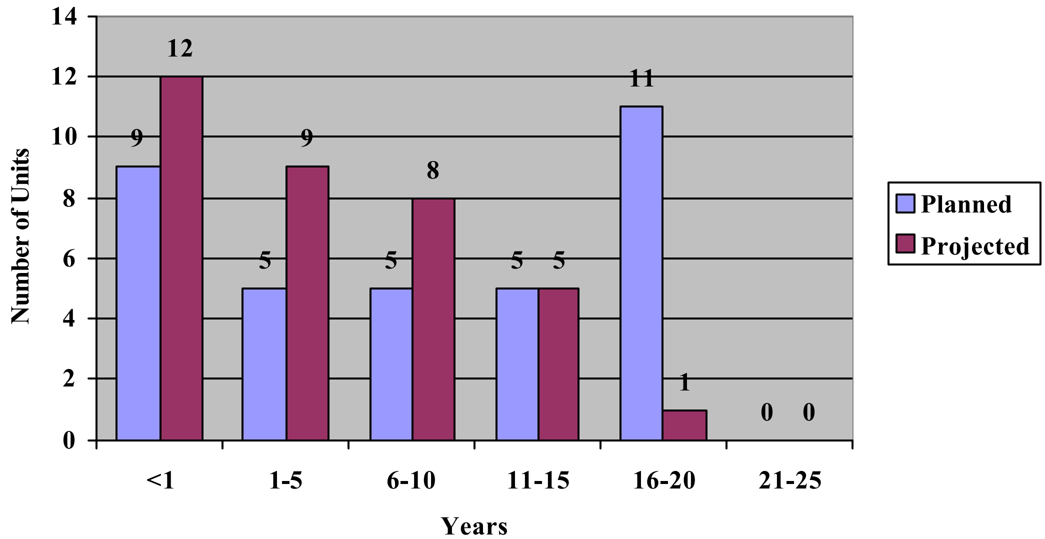

Figure C17. Comparison of NFPS planned fire apparatus replacement intervals with apparatus life span projections of NFPS fire apparatus operators.

Table B2

NFPS Fire Apparatus Data for Year Ending December 31, 1998

Unit	Age	Total Mileage	Annual Mileage	Unit Activity	Maintenance Cost	Cost Per Mile
E-01	1	17,846.0	7,294.0	1,555	3,707.00	.51
E-02	1	20,919.0	9,619.0	1,929	2,49.00	.25
E-04	8	51,264.0	7,481.0	1,262	11,659.00	1.56
E-06	12	99,218.0	3,859.0	1,052	9,186.00	2.38
E-07	8	47,873.0	3,735.0	1,014	3,419.00	.92
E-08	9	24,580.0	3,715.0	826	3,906.00	1.05
E-09	3	30,431.0	7,111.0	1,356	6,295.00	.89
E-10	7	72,040.0	10,790.0	1,671	7,350.00	.68
E-11	0	5,358.0	-	1,399	10.00	-
E-12	0	3,218.0	-	702	10.00	-
E-13	10	59,573.0	6,530.0	1,128	8,938.00	1.37
E-14	10	90,686.0	9,731.0	1,674	11,159.00	1.15
E-15	3	40,555.0	9,847.0	1,313	8,664.00	.88
E-16	1	17,742.0	7,296.0	946	1,894.00	.26
L-01	3	19,747.0	4,693.0	887	9,981.00	2.13
L-07	1	14,345.0	6,830.0	587	4,450.00	.66
L-08	15	48,564.0	1,882.0	263	24,000.00	12.75
L-09	1	14,769.0	5,655.0	571	7,084.00	1.25
L-10	24	49,016.0	5,704.0	723	15,413.00	2.70
L-13	17	72,984.0	4,313.0	472	6,542.00	1.52
L-14	0	5,560.0	-	755	-	-
S-01	8	138,517.0	18,443.0	1,829	18,035.00	.98
S-02	3	84,000.0	20,483.0	1,678	16,462.00	.80
RE-01	13	99,530.0	3,741.0	-	11,801.00	3.15
RE-02	29	121,162.0	3,482.0	-	4,595.00	1.32
RE-03	29	86,790.0	2,562.0	-	3,123.00	1.22
RE-04	29	149,939.0	4,723.0	-	13,161.00	2.79
RE-05	28	177,223.0	116.0	-	1,663.00	14.34
RE-06	24	89,091.0	2,330.0	-	1,720.00	.74
RE-07	20	89,431.0	14,190.0	-	4,553.00	.32
RL-01	35	141,137.0	209.0	-	7,742.00	37.04
RL-02	24	68,881.0	2,988.0	-	8,211.00	2.75
RL-03	17	34,050.0	890.0	-	5,273.00	5.92
RS-01	18	157,870.0	237.0	-	1,146.00	4.84
RS-02	16	142,400.0	1,925.0	-	2,192.00	1.14

Note. Apparatus ages are based on year of manufacture. Annual mileage totals are based on the differences between mileage totals for 1997 and 1998. Unit activity levels were unavailable for reserve apparatus. Annual mileage and cost per mile totals were unavailable for E-11, E-12, and L-14.

Table B3

Analysis of NFPS Fire Apparatus Ages (Years) for 1998

Apparatus Type	N	M	SD
Entire Fleet	35	13	10
First-Line Apparatus	23	7	6
Engines	14	6	4
Ladders	7	10	10
Squads	2	6	4
Reserve Apparatus	12	24	7
Engines	7	25	6
Ladders	3	25	9
Squads	2	17	1

Table B4

Analysis of NFPS Fire Apparatus Total Mileage (Miles) for 1998

Apparatus Type	N	M	SD
Entire Fleet	35	68,180.0	49,544.0
First-Line Apparatus	23	44,731.0	35,141.0
Engines	14	41,522.0	30,223.0
Ladders	7	32,141.0	24,837.0
Squads	2	111,258.0	38,549.0
Reserve Apparatus	12	113,125.0	41,996.0
Engines	7	116,167.0	35,311.0
Ladders	3	81,356.0	54,623.0
Squads	2	150,135.0	10,939.0

Table B5

Analysis of NFPS Fire Apparatus Annual Mileage (Miles) for 1998

Apparatus Type	N	M	SD
Entire Fleet	35	6,013.0	4,860.0
First-Line Apparatus	23	7,751.0	4,659.0
Engines	14	7,251.0	2,486.0
Ladders	7	4,846.0	1,698.0
Squads	2	19,463.0	1,442.0
Reserve Apparatus	12	3,116.0	3,799.0
Engines	7	4,449.0	4,532.0
Ladders	3	1,362.0	1,448.0
Squads	2	1,081.0	1,194.0

Table B6

Analysis of NFPS Fire Apparatus Unit Activity Levels (Emergency Responses) for 1998

Apparatus Type	N	M	SD
Entire Fleet	35	-	-
First-Line Apparatus	23	1,113	470
Engines	14	1,273	353
Ladders	7	608	205
Squads	2	1,754	107
Reserve Apparatus	12	-	-
Engines	7	-	-
Ladders	3	-	-
Squads	2	-	-

Table B7

Analysis of NFPS Fire Apparatus Total Maintenance Costs (Dollars) for 1998

Apparatus Type	N	M	SD
Entire Fleet	35	7,024.66	5,611.50
First-Line Apparatus	23	7,855.78	6,205.72
Engines	14	5,616.14	3,942.29
Ladders	7	9,651.43	7,902.77
Squads	2	17,248.50	11,12.28
Reserve Apparatus	12	5,431.67	4,011.83
Engines	7	5,802.29	4,728.12
Ladders	3	7,075.33	1,578.38
Squads	2	1,669.00	739.63

Table B8

Analysis of NFPS Fire Apparatus Maintenance Costs Per Mile (Dollars) for 1998

Apparatus Type	N	M	SD
Entire Fleet	35	3.45	6.92
First-Line Apparatus	23	1.73	2.67
Engines	14	.99	.59
Ladders	7	3.50	4.59
Squads	2	.89	.13
Reserve Apparatus	12	6.30	10.40
Engines	7	3.41	4.93
Ladders	3	15.24	18.95
Squads	2	2.99	2.62

Table B9

Performance Test Results of NFPS Fire Apparatus

		Current Pump Certification		Current Aerial Certification	
Unit	I.D. No.	Yes	No	Yes	No
E-01	9738		X		
E-02	9735		X		
E-04	9727		X		
E-06	9703		X		X
E-07	9728		X		
E-08	9729		X		
E-09	9733		X		
E-10	9730		X		
E-11	9741	X			
E-12	9740	X			
E-13	9713		X		X
E-14	9706		X		X
E-15	9734		X		
E-16	9739		X		
L-01	9731				X
L-07	9737			X	
L-08	9701		X		X
L-09	9736				X
L-10	9756				X
L-13	9761				X
L-14	9742			X	
S-01	9762				
S-02	9732				
RE-01	9702		X		
RE-02	9711		X		
RE-03	9712		X		
RE-04	9714		X		
RE-05	9715		X		
RE-06	9721		X		
RE-07	9726		X		X
RL-01	9754				X
RL-02	9758				X
RL-03	9760				X
RS-01	9778				
RS-02	9780				

Table B10

Ratings of Operating Condition of Essential Components of NFPS Fire Apparatus

Unit	I.D. No.	Cab	Body	Drive Train	Brakes	Suspension	Electrical
E-01	9738	4	4	5	5	4	4
E-02	9735	4	3	4	4	3	2
E-04	9727	4	4	4	2	3	4
E-06	9703	1	1	3	3	1	1
E-07	9728	3	3	3	1	2	2
E-08	9729	3	4	4	4	4	3
E-09	9733	3	2	3	3	2	2
E-10	9730	4	3	4	2	4	4
E-11	9741	5	4	4	5	5	1
E-12	9740	5	5	5	5	5	5
E-13	9713	2	2	3	1	3	3
E-14	9706	1	2	4	2	3	3
E-15	9734	3	3	3	3	2	2
E-16	9739	4	4	3	3	3	3
L-01	9731	5	4	5	5	5	4
L-07	9737	4	4	5	4	4	4
L-08	9701	3	3	2	2	3	3
L-09	9736	3	3	3	4	4	3
L-10	9756	1	1	2	3	2	1
L-13	9761	2	2	1	3	3	2
L-14	9742	5	3	4	3	4	3
S-01	9762	3	2	2	2	3	2
S-02	9732	3	1	3	3	2	3
RE-01	9702	2	2	3	3	1	3
RE-02	9711	2	3	3	3	3	3
RE-03	9712	1	1	2	2	1	2
RE-04	9714	1	1	1	2	1	2
RE-05	9715	2	2	3	3	2	2
RE-06	9721	1	1	3	3	2	3
RE-07	9726	1	1	1	2	1	1
RL-01	9754	1	1	2	2	2	2
RL-02	9758	2	1	1	2	1	2
RL-03	9760	3	1	1	2	1	2
RS-01	9778	1	1	1	1	1	1
RS-02	9780	3	3	3	2	2	2
	<u>N</u>	35	35	35	35	35	35
	<u>M</u>	2.7	2.4	2.9	2.8	2.6	2.5
	<u>SD</u>	1.34	1.22	1.24	1.12	1.26	1.01

Table B11

Ratings of Operating Condition of Systems and Equipment of NFPS Fire Apparatus

Unit	I.D. No.	Fire Pump	Foam System	Booster Tank	Aerial	Ancillary Systems
E-01	9738	5	5	5		5
E-02	9735	4	3	3		3
E-04	9727	5		3		
E-06	9703	1		3	2	
E-07	9728	4		3		
E-08	9729	2		5		
E-09	9733	4	4	4		4
E-10	9730	5		4		
E-11	9741	5	4	5		5
E-12	9740	5	4	5		5
E-13	9713	3		2	3	
E-14	9706	3		3	2	
E-15	9734	4	2	2		4
E-16	9739	3	3	3		4
L-01	9731				5	4
L-07	9737				5	5
L-08	9701	3		3	3	
L-09	9736				4	4
L-10	9756				2	
L-13	9761				2	2
L-14	9742				5	5
S-01	9762					3
S-02	9732					3
RE-01	9702	2		2		
RE-02	9711	2		3		
RE-03	9712	3		2		
RE-04	9714	2		1		
RE-05	9715	1		1		
RE-06	9721	3		2		
RE-07	9726	1		1	1	
RL-01	9754				1	
RL-02	9758				2	
RL-03	9760				1	
RS-01	9778					1
RS-02	9780					3
	N	22	7	22	14	16
	M	3.2	3.6	3.0	2.8	3.7
	SD	1.37	.98	1.29	1.54	1.20

Table B12

Performance Levels of NFPS Fire Apparatus

		Is the apparatus reliable?		Does the apparatus meet mission?	
Unit	I.D. No.	Yes	No	Yes	No
E-01	9738	X		X	
E-02	9735	X		X	
E-04	9727	X		X	
E-06	9703	X		X	
E-07	9728	X		X	
E-08	9729	X		X	
E-09	9733	X		X	
E-10	9730	X		X	
E-11	9741	X		X	
E-12	9740	X		X	
E-13	9713		X	X	
E-14	9706	X		X	
E-15	9734		X	X	
E-16	9739	X		X	
L-01	9731	X		X	
L-07	9737	X		X	
L-08	9701	X			X
L-09	9736	X		X	
L-10	9756	X			X
L-13	9761	X			X
L-14	9742	X		X	
S-01	9762	X			X
S-02	9732	X			X
RE-01	9702		X		X
RE-02	9711		X		X
RE-03	9712		X		X
RE-04	9714		X		X
RE-05	9715		X		X
RE-06	9721		X		X
RE-07	9726		X		X
RL-01	9754		X		X
RL-02	9758		X		X
RL-03	9760		X		X
RS-01	9778		X		X
RS-02	9780		X		X

Table B13

Comparison of Planned Replacement Intervals and Projected Life Expectancy of NFPS Fire Apparatus

NFPS Planned Intervals			NFPS Fire Apparatus Operator Projections					
Unit	I.D. No.	Remaining Years	<1 Year	1-5 Years	6-10 Years	11-15 Years	16-20 Years	21-25 Years
E-01	9738	19			X			
E-02	9735	19			X			
E-04	9727	12				X		
E-06	9703	8		X				
E-07	9728	12		X				
E-08	9729	12			X			
E-09	9733	17			X			
E-10	9730	13			X			
E-11	9741	20			X			
E-12	9740	20				X		
E-13	9713	10		X				
E-14	9706	10		X				
E-15	9734	17		X				
E-16	9739	19				X		
L-01	9731	17			X			
L-07	9737	19					X	
L-08	9701	5		X				
L-09	9736	19				X		
L-10	9756	0	X					
L-13	9761	3		X				
L-14	9742	20				X		
S-01	9762	7		X				
S-02	9732	12			X			
RE-01	9702	7	X					
RE-02	9711	0		X				
RE-03	9712	0	X					
RE-04	9714	0	X					
RE-05	9715	0	X					
RE-06	9721	0	X					
RE-07	9726	0	X					
RL-01	9754	0	X					
RL-02	9758	0	X					
RL-03	9760	3	X					
RS-01	9778	2	X					
RS-02	9780	4	X					

Table B14

Demographic Profiles of Cities/Counties Participating in Survey of Fire Apparatus Replacement Practices of Fire Departments in the Tidewater Metropolitan Area

City/County	Population	Area (Sq. Miles)	Population Density
Chesapeake, Va.	200,000	350.0	571.4
Hampton, Va.	141,182	51.8	2,715.0
Newport News, Va.	180,000	68.0	2,647.1
Portsmouth, Va.	100,000	34.0	2,941.2
York County, Va.	56,000	108.0	518.5
Virginia Beach, Va.	432,000	311.0	1,389.1

Table B15

Fire Apparatus Profiles of Cities/Counties Participating in Survey of Fire Apparatus

Replacement Practices of Fire Departments in the Tidewater Metropolitan Area

	First-Line Apparatus			Reserve Apparatus		
City/County	Engines	Ladders	Squads	Engines	Ladders	Squads
Chesapeake, Va.	17	3		5	1	
Hampton, Va.	10	2	1	3		
Newport News, Va.	13	6	2	3	1	
Portsmouth, Va.	10	3		2	1	
York County, Va.	8	1	2	2		
Virginia Beach, Va.	20	5	1	6	2	

NATIONAL FIRE ACADEMY
EXECUTIVE FIRE OFFICER PROGRAM
FIRE APPARATUS SURVEY

UNIT: [UNIT NUMBER] **I.D. NUMBER:** [CITY I.D. NUMBER]

PART I: ASSESSMENT OF OPERATING CONDITION

DIRECTIONS: Please rate the current condition of the following essential components, systems, and equipment of the fire apparatus to which you are assigned. A "5" is the highest score, and a "1" is the lowest score (circle one for each category). Circle "Not Applicable" for any components or systems that do not apply to your apparatus.

1. **CAB ASSEMBLY** (including metal skin and structural components, doors and windows, paint, and interior upholstery):

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

2. **BODY ASSEMBLY** (including metal skin and structural components, compartments, shelving and trays, and compartment doors):

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

3. **DRIVE TRAIN** (including engine and transmission):

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

4. **BRAKING SYSTEM** (including vehicle brakes, parking brakes, and secondary braking device if applicable):

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

5. **SUSPENSION SYSTEM** (including struts, shock absorbers, and leaf springs):

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

6. **ELECTRICAL SYSTEM** (12-volt electrical system including the cab and body electrical system, instruments and gauges, and emergency warning lights):

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

7. **FIRE PUMP** (including instruments and gauges, intake and discharge piping):

Poor	Fair	Good	Very Good	Excellent	Not Applicable
1	2	3	4	5	N/A

8. **FOAM PROPORTIONING SYSTEM** (including metering valve, discharge piping, and auxiliary intake):

Poor	Fair	Good	Very Good	Excellent	Not Applicable
1	2	3	4	5	N/A

9. **BOOSTER TANK** (including water tank, and foam tank if applicable):

Poor	Fair	Good	Very Good	Excellent	Not Applicable
1	2	3	4	5	N/A

10. **AERIAL DEVICE** (including aerial ladder or telescoping boom, and associated outrigger system):

Poor	Fair	Good	Very Good	Excellent	Not Applicable
1	2	3	4	5	N/A

11. **ANCILLARY SYSTEMS AND EQUIPMENT** (including 110-volt on-board electrical generators, electrical cable reels, air compressors and cascade systems, pneumatic and hydraulic rescue systems, and scene lighting systems):

Poor	Fair	Good	Very Good	Excellent	Not Applicable
1	2	3	4	5	N/A

PART II: ASSESSMENT OF PERFORMANCE

DIRECTIONS: Please circle the response that best answers the following questions.

1. Is the performance of this apparatus consistently reliable at emergency incidents?

Yes **No**

2. Do the performance capabilities of this apparatus meet the current mission requirements of the Norfolk Department of Fire and Paramedical Services?

Yes **No**

PART III: PROJECTION OF REMAINING USEFUL LIFE SPAN

DIRECTIONS: Please circle the response that best answers the following question.

1. Based on the current operating condition, reliability, and performance capabilities of this apparatus, what is a reasonable projection of the remaining useful life span for this vehicle?

Less Than 1 Year	**1-5 Years**	**6-10 Years**	**11-15 Years**	**16-20 Years**	**21-25 Years**

[DATE CODE]

[FIRST NAME, LAST NAME, TITLE]
[FIRE DEPARTMENT]
[ADDRESS]
[CITY, STATE, ZIP CODE]

Dear [TITLE, LAST NAME]:

The purpose of this letter is to request your assistance with a survey I am currently conducting to obtain information about the fire apparatus replacement practices of other fire departments in the Tidewater area. The results of this survey will be included in an applied research project for the National Fire Academy as part of the Executive Fire Officer Program.

Will you please take the time to complete the enclosed survey and return it to me in the enclosed envelope by April 30, 1999? If you have any questions, please feel free to contact me at Station 3, [PHONE NUMBER] or pager [PAGER NUMBER]. Your assistance with this survey is appreciated.

Sincerely,

Edward L. Senter Jr.
Battalion Chief

Enclosure

NATIONAL FIRE ACADEMY
EXECUTIVE FIRE OFFICER PROGRAM
SURVEY OF FIRE APPARATUS REPLACEMENT PRACTICES OF FIRE DEPARTMENTS IN THE TIDEWATER METRO AREA

CITY/COUNTY: ____________[LOCALITY]__________

DIRECTIONS: Please answer the following questions about your city, the first-line and reserve apparatus in your department, and the variables that are factored into fire apparatus replacement decisions in your department.

PART I: <u>DEMOGRAPHIC INFORMATION</u>

1. Population served by your department: ____________________________

2. Area served by your department (square miles): ____________________________

PART II: <u>FIRE APPARATUS INFORMATION</u>

1. First-Line Fire Apparatus (place N/A next to units that do not apply):

- **a.** Total number of first-line engines: ____________________________
- **b.** Total number of first-line ladders: ____________________________
- **c.** Total number of first-line squads: ____________________________

2. Reserve Fire Apparatus (place N/A next to units that do not apply):

- **a.** Total number of reserve engines: ____________________________
- **b.** Total number of reserve ladders: ____________________________
- **c.** Total number of reserve squads: ____________________________

PART III: <u>FIRE APPARATUS REPLACEMENT VARIABLES</u>

1. Please describe the variables that are factored into fire apparatus replacement decisions in your department (i.e. age, mileage, maintenance costs, etc.). Please list any innovative approaches your fire department employs in assessing fire apparatus for replacement.

____
____
____
____